SEPTEMBER 4, 1961

missiles and rockets

THE MISSILE/SPACE WEEKLY

THE UNIVERSITY OF MICHIGAN
SEP 6 1961
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Centaur Hits Delay— U.S. Space Schedule Upset

- Martin Tells Of ASP Concept
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First Ranger Launching

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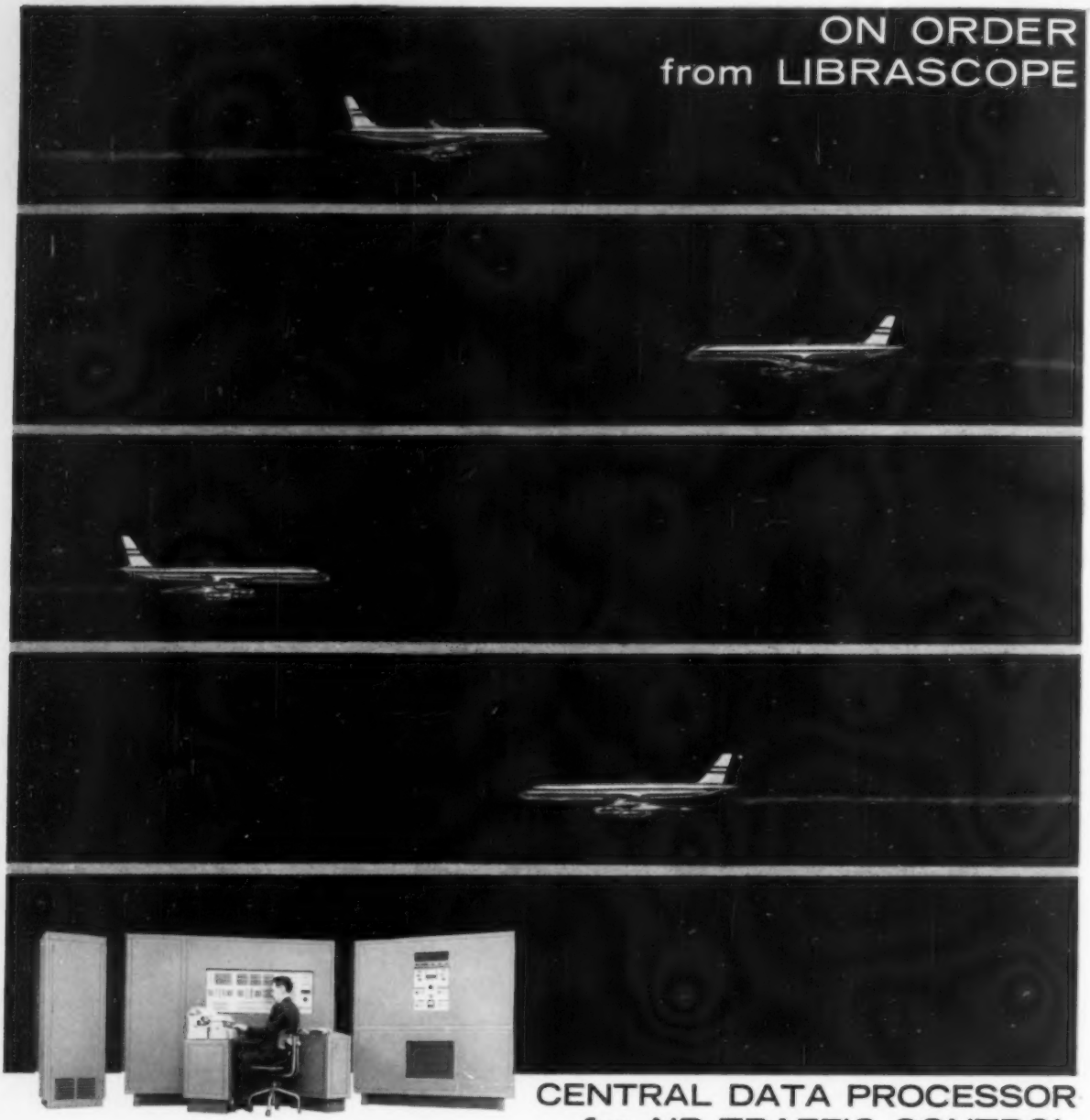

CENTRAL DATA PROCESSOR for AIR TRAFFIC CONTROL

Today, at a peak traffic hour, approximately 200 aircraft flew over the New York area. Each year this number will increase. Yet, the Federal Aviation Agency will continue to assure safe and efficient control of air traffic. One reason . . . a data processor developed for the FAA by Librascope to quickly and accurately handle the routine clerical tasks now occupying most of the controller's time. The first 18-unit data processor will be installed at Boston in 1962. A note to Librascope outlining your control problems will bring a prompt answer from the country's most versatile manufacturer of computer control systems.

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CREATIVE CONTROVERSY IN INERTIAL GUIDANCE

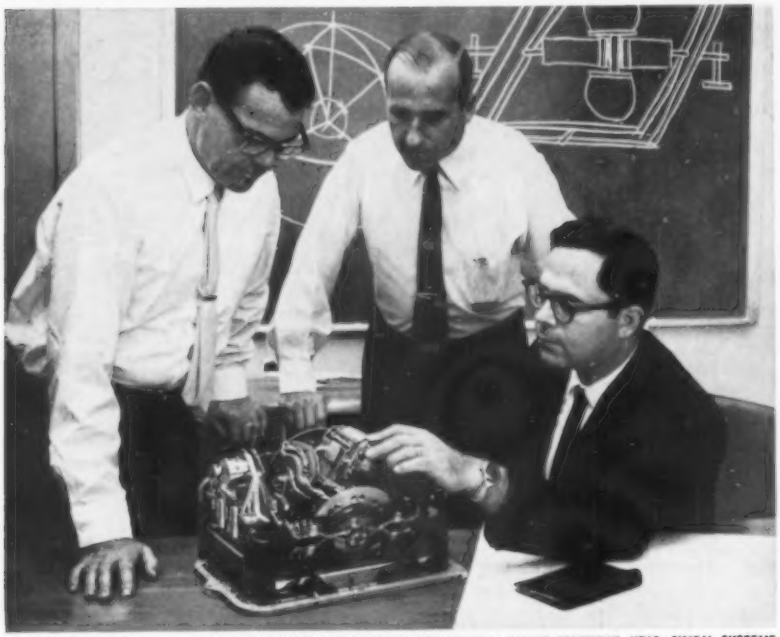
Behind the inertial package you see here is the instructive history of a creative controversy.

It's the history of how the ingenious rebuttals of some Litton Systems people won an engineering debate by overcoming certain obstacles that had been roadblocking progress in airborne inertial navigation.

The equipment shown is the stable-platform unit of a Litton LN-3 navaid system, first to furnish operational aircraft with inertial navigation information to an accuracy within 1.5 nautical miles for each hour of varied flight maneuvers.

The debate: It had been known that an inertial platform could be built around two two-degree-of-freedom gyros in place of the three one-degree-of-freedom gyros that were the standard concept. And that such a change would offer a number of important advantages including high gyro angular momentum in a compact platform, better servo response characteristics, and freedom from air-bubble problems achieved through the use of low-viscosity damping fluid.

Many inertial engineers felt strongly that the difficulties encountered in trying to manufacture two-degree-of-freedom gyros would more than offset the promised benefits. The difficulty regarded with the most superstitious awe was the problem of adjusting the center of gravity, center of buoyancy and total weight of the float containing the gyro to achieve neutral buoyancy at a specified temperature and zero torque about all three axes, within extremely narrow tolerances.



L-R: BRUCE SAWYER, HEAD OF ELECTROMECHANICAL ENGINEERING DEPARTMENT; GEORGE NORTHWAY, HEAD, GIMBAL SYSTEMS ENGINEERING; HAROLD ERDLEY, DIRECTOR OF ELECTROMECHANICAL PRODUCTS, GUIDANCE & CONTROL SYSTEMS DIVISION.

The additional restriction, that the weights placed on the float for balancing shall fall between a minimum and a maximum allowable size, increases the complexity of the actual balance procedure, placing it in the "linear programming" category from a computer standpoint.

The problem was solved by being programmed for solution on a digital computer in order to provide an efficient and reliable balancing process in production. The success of this approach is demonstrated by the world-wide operation of the Litton LN-3 aircraft navigation system, a proven lightweight system of high accuracy that uses two-degree-of-freedom gyros.

The same approach is being used to expedite the development of even more advanced systems, which will assure Litton's dominant position in the field. They include the Litton Doppler-Inertial System for the P3V anti-submarine patrol aircraft and the P-300 inertial platform of the Air Force Flight Data System for orbital and sub-orbital vehicles.

It's good to work in the atmosphere engendered when management fully appreciates the value of creative controversy that produces such results. Like-minded design and production engineers with applicable experience couldn't do better than to contact N. M. Pagan, Litton Systems, Inc., Guidance & Control Systems Division, 5500 Canoga Avenue, Woodland Hills, California.

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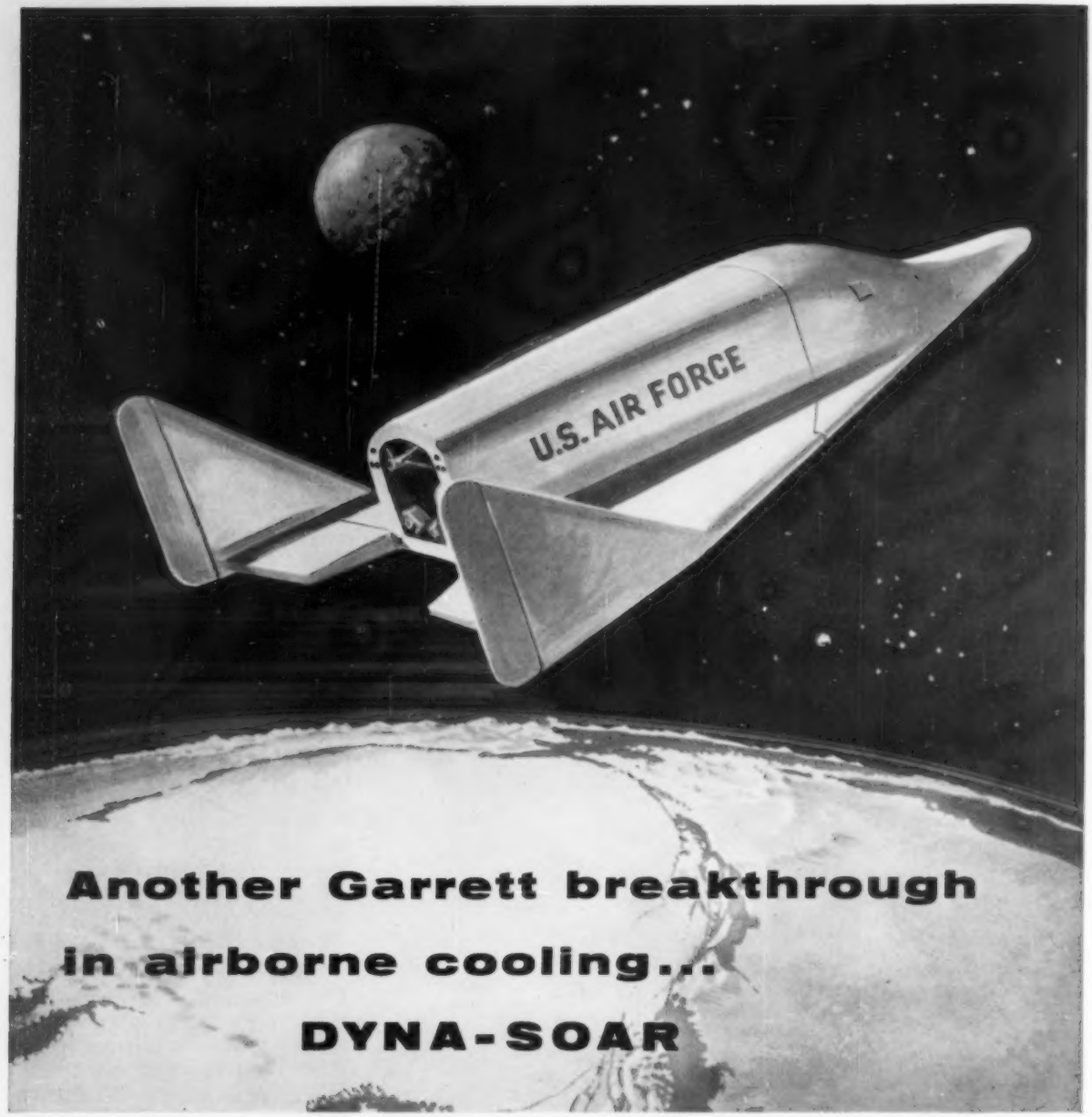

Another Garrett breakthrough in airborne cooling... DYNA-SOAR

Boeing Dyna-Soar Manned Space Glider

Garrett is now developing Dyna-Soar's thermal control system — again demonstrating its 20-year leadership in the pioneering of airborne cooling methods by its AiResearch Manufacturing Divisions.

An important contribution to the rapid over-all development of the Boeing Dyna-Soar manned space glider, the compact, lightweight system will cool the pilot and his equipment, economically utilizing the cryogenic hydrogen fuel of the accessory power system.

The development of this hydrogen system exemplifies Garrett's continuing advancements in airborne cooling, including air cycle and Freon refrigeration systems, zero gravity gas and liquid systems, and new developments in space radiators and other systems using exotic liquids and metals... all leading to the development of more advanced thermal control techniques for spacecraft.

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THE MISSILE / SPACE WEEKLY

missiles and rockets

Volume 9, Number 10 September 4, 1961

THE COVER

Ranger I launched Aug. 23 failed to go into planned orbit when Agena B stage did not restart. Backup shot is due next month. NASA has ordered 4 more Rangers.

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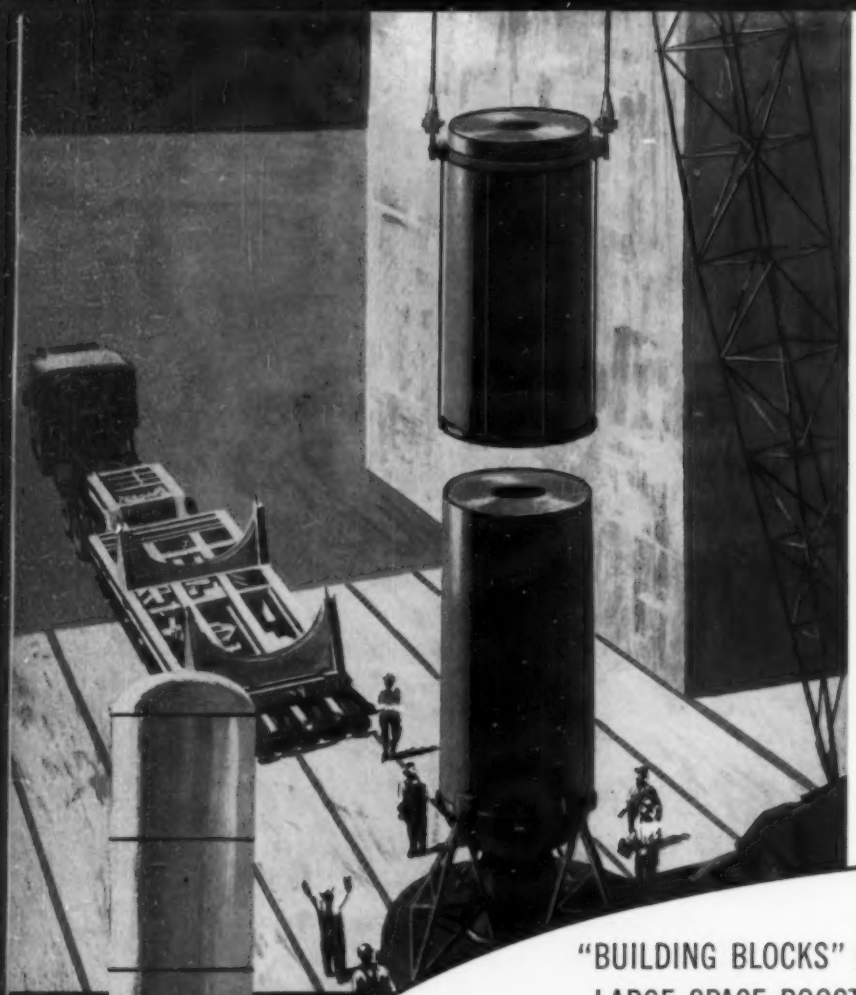
Published each Monday with the exception of the last Monday in December by American Aviation Publications, Inc., 1001 Vermont Ave., N.W., Washington 5, D.C. Cable Address: AMERAV.

Printed at Judd & Detweiler, Inc., Washington, D.C. Second class postage paid at Washington, D.C. Copyright 1961, American Aviation Publications, Inc.

Subscription rate: U.S. and Possessions, Canada, and Pan American Postal Union Nations: 1 year $5.00, 2 years $8.00, 3 years $10.00. All other foreign: 1 year $15.00, 2 years $25.00, 3 years $35.00. Single copy prices: regular issues 50 cents each; special issues $1.00 each. Subscriptions are solicited only from persons with identifiable commercial or professional interests in the missile/space industry. Subscription orders and changes of address should be referred to Circulation Fulfillment Mgr. Missiles and Rockets, 1001 Vermont Ave., N.W., Washington 5, D.C. Please allow 4 weeks for change to become effective and enclose recent address label if possible.



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memo from the publisher

Senior Editor Baar

ONE OF THE MOST difficult assignment on MISSILES AND ROCKETS involves probing the bureaucratic maze of Washington and pinpointing the significant trends and decisions affecting the missile/space industry as they are being made—the decisions that really count.

For almost three years now, the man who has been performing this important job with consistent lucidity and pungency is James Baar, our editor for military affairs. Many of you readers have noted his unerring eye, and so it is with considerable pleasure that we draw your attention to our masthead, which shows that we have just made Jim a Senior Editor.

This is a new editorial post on M/R and one which Jim's talents have rightly earned.

By a pleasant coincidence, this promotion comes as the latest book written by Jim and Managing Editor Bill Howard — *Combat Missileman* — is being published by Harcourt Brace & World. The book is a definitive account of the key political and strategic decisions we have seen shape the building of our big missile strike force, and it gives the reasons why we stand where we do today.

Combat Missileman follows hard on the heels of *Polaris!*, authored by this same M/R team last year, and hailed, as one critic put it, as a "can't-put-it-down-until-I'm-finished book."

They have, as sharp-eyed interpreters of what goes on inside this intricate field of ours, also produced articles for mass circulation magazines — all of which, it can be hoped, will add to public understanding of the difficulties we all face in the Space Age.

Interpreting Washington for you in the missile/space industry is, as might be imagined, no easy assignment. A day in the life of our military affairs editor involves a lot of footwork as well as brainwork.

Jim Baar ranges from the Pentagon . . . to Congress . . . to the White House . . . and frequently further afield in the never-ending hunt to find the people who will provide the answers and the facts. They may be admirals, generals, industry reps, the key man on a committee, a company president.

Over the years, Jim's by-line has appeared over many of our lead articles and exclusive stories, from AUTEC to *Nike-Zeus*, from what Congress may do about "non-profits" to the real reasons why we are going into space.

To get these and other significant stories, he has ridden in missile-carrying jet aircraft, walked in the bottom of an *Atlas* silo and even steered a nuclear-powered submarine. Never one to let a story pass by, he took the pictures of the Antigua downrange station (page 16) while vacationing there recently.

"It all may sound rather colorful," says Jim, "but it adds up to one thing: work!"

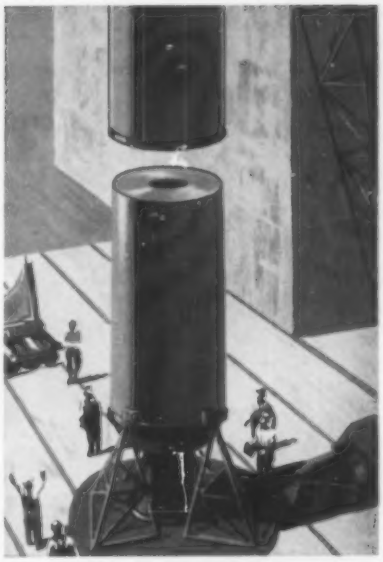
He tops this off by allowing that he usually goes to bed at night reading a transcript of congressional testimony.

Before we lured him away, Jim was applying his energy to covering Capitol Hill and the space field for United Press International. He was with UPI for 10 years, becoming an expert on the ins and outs of the government's decision-making process as well as a highly proficient writer.

Jim lives in Alexandria, Va., with his wife and son and a five-year-old schnauzer named Rupert, who he suspects may be thinking of writing a play.

Perhaps surprising in light of his present occupation, Baar majored in philosophy while in college. But he insists that this is what enables him to interpret the intricate maneuvering and sometimes cloudy thinking that seem to be present in Washington.

Edward Muhlfeld



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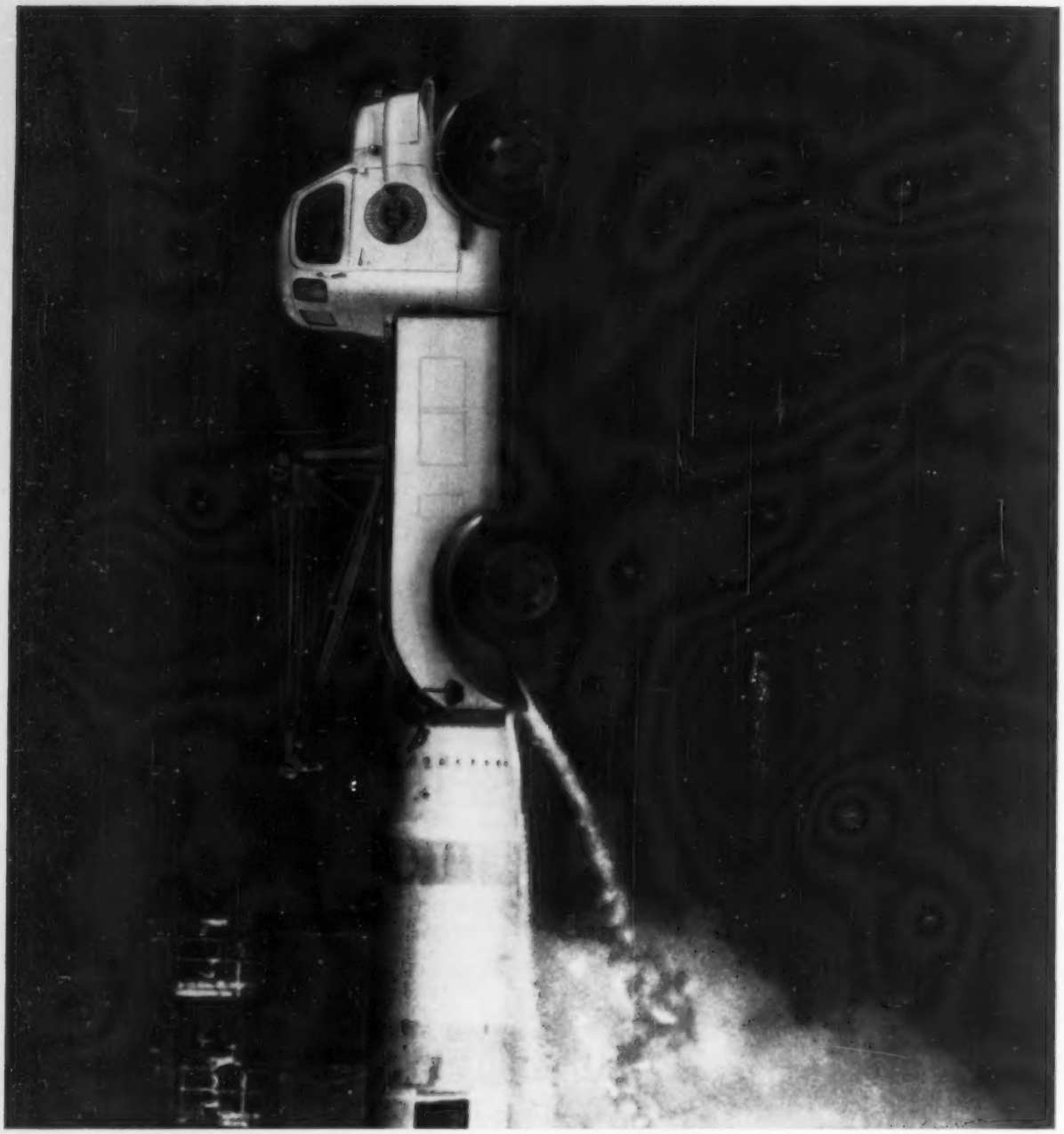

How do you service a satellite?

The instant a manned satellite goes into orbit, the question of service becomes critical. How do you handle routine or emergency maintenance and repair, for instance? What about getting replacement parts up there, supplying food and other necessities, or removing and replacing personnel?

At Northrop a special task force has been assigned to explore the complex technical problems involved and come up with practical recommendations. They are giving particular attention to such areas as the design of a general shuttle vehicle, close-in rendezvous and docking techniques, requirements for manned maintenance at all levels, and methods for transfer of men, materials and equipment under conditions of weightlessness.

Not all the problems are solved yet, even on paper. But a surprising number of practical answers have been found. That's Northrop's special strength . . . finding realistic answers to the problems of the space age, and translating them into working hardware.

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The Countdown

WASHINGTON

Space Policy: A Switch?

Evidence of a possible sharp switch in the Administration's thinking about space has cropped up. Associate NASA Administrator Robert Seamans, Jr., says publicly that if Russia surpasses the United States in space "their space technology in its military aspects will be used to jeopardize our security." Until now, no top Administration official has more than mumbled obliquely that Russia's drive into space is an overt threat to the national security.

Military Missions in Space

The Air Force has officially pinpointed 12 military missions for spacecraft, satellites and missiles of various types. The missions are: Communications, cargo and logistic support, fueling, early warning, interception-defense, reconnaissance, strategic, target, launching, weather, test and research.

Apollo May Go Sooner

NASA is in the process of making a possible new revision in its *Apollo* man-to-the-moon program. President Kennedy said earlier this year that the United States would attempt to put a man on the moon within the decade of the 1960's. This was generally interpreted—officially and unofficially—as meaning close to 1970. Now NASA is studying whether it may be possible by 1967 or 1968.

But More Waiting for Mercury

The chances of orbiting a manned *Mercury* this year grow increasingly slighter. The orbiting of an unmanned *Mercury*, planned for August, now will not be attempted until about Sept. 15 or later. The reason given by NASA: Problems in the *Atlas* booster programs, including the finding of solder filings.

For Polaris: A Packaged Liquid?

Navy studies looking into the possibilities of developing a follow-on 4000-to-5000-mile-range *Polaris* are weighing a possible switch from solid propellants to packaged liquids. However, there is strong opposition within the Navy to taking large quantities of liquid propellant aboard ships.

For TAC: An Army-AF MRBM?

The Tactical Air Command is pressing again for development of a 1000-mile medium range ballistic missile. And the build-up of limited war forces could open the way for development of a bi-service Army-AF model. It probably would be based on an upgraded version of the Martin *Pershing*.

INDUSTRY

Labor-Management Troubles Hit AEC

AEC officials at the Los Alamos Scientific Laboratory say nuclear rocket and other programs are being plagued by labor and contractor problems. In one instance, guards walked off their posts at the Nevada test site without notice. The facility was left with no security until more guards could be flown in from other AEC installations. Delays in some programs are said to be the fault of contractors as well as the plumbers, electricians and teamsters unions.

R&D Intelligence

NASA is studying the possibility of using the *Surveyor* lunar soft-landing spacecraft as a lunar-orbiter for a complete reconnaissance to help the man-in-space program. . . . Specs call for building firefighting equipment right into the *Nova* moon-boosters. . . . Electrical discharge forming is under investigation by NASA-Huntsville as a method of building 300-in. and larger tanks for *Saturn* and *Nova* vehicles. . . . Westinghouse is developing a 400-cycle turbo-generator to power the Navy's *Typhon* antimissile missile.

The Cape Is It

If a second launch center has to be developed just for *Nova*-type solid boosters, some NASA officials are saying the solid will have to be scrapped. The reason: the nation "can't afford" to spend another $500 million on top of the new Cape Canaveral expansion (see page 15) for a second launch complex. A committee studying the problem is expected to come up with the answer that both liquid and solid *Novas* can go from the Cape.

ComSat Cannonade

Expect the Senate Small Business Subcommittee on Monopoly to fire away at FCC handling of the commercial communications satellite ownership question when it begins hearings in mid-October. The hearings will start just after an ad hoc committee of the international telephone companies submit their ownership plan to the FCC.

INTERNATIONAL

West Germans Prepare Space Budget

The West German space program now being organized is expected to have an initial budget of from about $44 million to possibly as much as $56 million. About half of the money will be spent on a West German national program, the remainder on the West European space program. Two particularly hot projects are development of a communications satellite and mail-delivering rockets.

India Makes and Buys New Missiles

India is working on development of its own air-to-air missiles, presumably for use on its new supersonic fighters. At the same time, the Indians are reported to be interested in buying antitank missiles from Western Europe.

Overseas Pipeline

SEPR is increasing its capitalization by about 50%. . . . Informed speculation in Europe now says the *Vostok III* expected to be launched late this fall probably will remain in orbit about one week. . . . The Nationalist Chinese are planning an extensive rocket research program on Formosa.

What will the Surveyor find on the moon?

Sometime in 1963, this spacecraft will land on the moon. In it will be over 200 pounds of scientific instruments designed to gather, analyze and transmit information about the moon's surface, subsurface and atmosphere.

The Hughes-designed Surveyor will be built to "soft land." As it approaches the moon, after a 66-hour flight from the earth, retro-rockets will be fired to cushion the impact of landing.

Then, standing on three legs, the 750-pound moon explorer will set to work—as scientists here on earth watch via television. High-quality television pictures of the lunar landscape will be taken and transmitted. Drills will pierce the moon's surface and samples will be brought up into the spacecraft for chemical analyses. Other instruments will measure the geophysical characteristics of the lunar surface, as well as the moon's magnetic and radiation fields.

Hughes will build seven Surveyor vehicles which are scheduled to be launched at Cape Canaveral during the period 1963-66. The work is being performed for the National Aeronautics and Space Administration. Technical direction is by the California Institute of Technology Jet Propulsion Laboratory.

The information which Surveyor gives us will be an important step toward the day when man himself will stand on the moon and look out into the universe.

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The Missile/Space Week

Soviets to Resume Nuclear Missile Tests

Russia announced last week that it is resuming nuclear tests—opening the way for extensive development of whole new families of missiles—both tactical and strategic.

It also opens the way for development of space weapons far more powerful than any nuclear weapon now in the arsenals of the East or West.

Many U.S. officials have suspected that Russia has been cheating on the test ban for some time, thereby gaining a significant march on the United States in the development of advanced nuclear weapons.

One informed guess on why the Soviets announced ending the ban at this time is that they wish to test weapons of such power that the tests could no longer be concealed.

Minuteman Silo Shot Fails

The first attempt to launch an untethered *Minuteman* from a silo Aug. 30 ended in a flaming failure.

The three-stage solid ICBM roared from its narrow silo at the Cape and exploded seconds after clearing the ground.

The launching was the fourth in the Cape test series. The box score: Two successes, one partial, one failure.

NASA Orders More Rangers

Four *Rangers* have been added to the U.S. lunar exploration program.

Orders for the new spacecraft—with a pricetag of $20 million each—brings the total number in the *Ranger* program to nine.

NASA is already negotiating a contract with RCA's Astro/Electronics Div. for TV cameras *Ranger* will carry to send high-resolution TV pictures of the lunar surface back to earth.

Discoverer Monkey Scratched

Long-postponed plans to orbit a monkey in a *Discoverer* capsule now have been scrapped altogether.

The Air Force apparently is planning to join NASA in an animal-orbital program, instead.

Meantime, the Air Force polar-orbitted its 29th *Discoverer* satellite on Aug. 30. A recovery attempt was to be made of an instrumented capsule.

Gen. Bernard Schriever, chief of the Air Force Systems Command, said the decision to drop plans to orbit a monkey for four days and recover him came about because of conflict with other Air Force programs.

Short-lived Explorer

EXPLORER XIII micrometeoroid satellite was launched aboard a Scout vehicle Aug. 25 from Wallops Island, Va. It re-entered the atmosphere on Aug. 29.

Missile Frigates Ordered

The Navy last week awarded contracts for three guided missile frigates to be built under its ship construction program for the current fiscal year.

The Puget Sound Naval Shipyard will build two frigates, to be armed with missiles, antisubmarine rockets, torpedoes and conventional guns. The third ship will be built by the San Francisco Naval Shipyard.

Titov Has No Ill Effects

A Soviet space scientist says prolonged weightlessness had no effect on Gherman Titov's work capacity, bodily functions or nervous system during 25 hours in orbit.

Mariner hardest hit . . .

Centaur Slippage Fouls Plans

Extra three-to-four month setback will delay first Atlas-Centaur firing until next year; main trouble is inexperience.

By Hal Taylor

FIRST FLIGHT of NASA's hydrogen-oxygen *Centaur* booster is slipping into 1962. The new delay is playing havoc with planetary, lunar and satellite flight schedules.

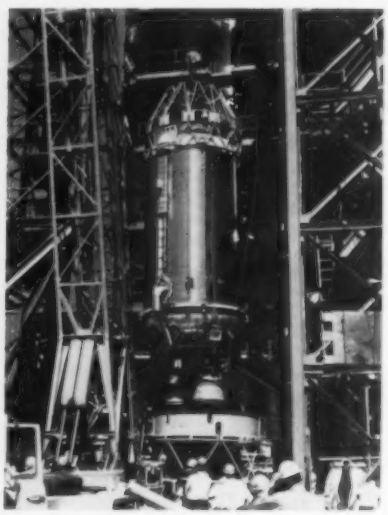
MISSILES AND ROCKETS learned this week that NASA now is anticipating a three-to-four-month additional delay in the first test of *Atlas-Centaur*, forcing a re-evaluation and rejuggling of schedules.

Originally, *Centaur* was to have been launched in June. This subsequently was moved back to the last of this year. The new delay will move the shot into 1962.

The program most affected is the *Mariner* fly-by of Venus, which was set for mid-1962, the next optimum period for a shot at the planet. Since three test flights of *Centaur* are needed prior to the fly-by attempt, it appears almost certain that the booster vehicle will not be ready until next fall—about three months late.

Venus will not be in position for another fly-by attempt until 1964. But NASA is making provisions for a substitute *Mariner* launcher, probably an *Atlas-Agena B*.

The slippage may also delay the scheduled launch late next year of the first Army *Advent* active repeater communications satellite and affect the timetable for the first *Surveyor* lunar soft-landings in 1963.



CENTAUR to be used as second stage with Atlas is raised in gantry at Canaveral.

• **Production jam-up**—Development delays, moreover, are squeezing the *Centaur* production schedule. Beginning in 1963, 10 *Centaurs* are scheduled for use as the second stage of *Saturn C-1*. This demand could create a shortage of *Centaurs* for other space programs. *Saturn-Centaurs* have nine RL-10 10,000-lb-thrust engines, and *Atlas-Centaurs* have two 15,000-lb.-thrust engines.

Col. Daniel D. McKee, technical assistant to the director of NASA's Office of Launch Vehicle Programs, contends that there is still a 50-50 chance that the first *Centaur* will be launched by the end of the year.

NASA's Space Flight Office has already been told, however, to find a substitute for *Centaur* in the *Mariner* program. The *Mariner* shots were to use No's. 4 and 5 of the *Centaur* vehicles and were scheduled for launch in August, 1962.

They are expected to pick the *Atlas-Agena B*, which can only boost 750 lbs. to escape velocity, compared to *Centaur* payloads of 1500 lbs. As a result, it is certain that the *Mariner* payloads will have to be scaled down considerably.

Numbers 6, 7, and 8 in the *Centaur* series were slated to boost joint NASA-DOD payloads. The first two in late 1962 and the third in early 1963. The DOD payloads will be in conjunction with *Advent* and NASA's will be a piggyback geophysical experiment.

Twenty *Centaurs* have been ordered, with numbers 9 through 20 scheduled for *Surveyor* and the *Saturn* programs.

NASA is pumping $56 million into *Centaur* in FY '62. Under the original *Centaur* schedule, the first three launches of the vehicle were to be completed by late 1961.

• **Sources of trouble** — Ignition problems with the simultaneous start of its two RL-10 LOX-liquid hydrogen engines has caused most of the present slippage and resulted in three explosions at the Pratt & Whitney engine development center at West Palm Beach, Fla.

The two engines must start within milliseconds of each other. Otherwise, hydrogen and oxygen soon build up to an explosive mixture in the closed chamber used for the engine tests.

New problems have developed which are not of major significance, but their solution has forced further delay into the program to the point that further slippage of the launch date into 1962 is considered likely.

The overall problem of the *Centaur* program, according to NASA officials, is that it is a pioneering development which is pushing the state of technology every step of the way. Previous experience in the use of supercold (−428°F) liquid hydrogen as fuel was limited to research programs. And, to complicate matters, LOX and liquid hydrogen are not hypergolic. An ignition system is required. ⌗

NERVA flight in '65? . . .

Nuclear Stage Key to Moon Trips

A NUCLEAR third stage would give *Nova* and *Saturn* boosters the capability of direct flights to the moon —perhaps by NASA's 1967 target date for manned moon landings.

A crucial series of tests on the Kiwi-B reactor in October and early next spring holds the key. If these succeed, NASA officials believe, the nuclear rocket engine, *NERVA*, can be test-flown in 1965. This would probably make it possible to mate a nuclear third stage with either a four-F-1-engine *Nova* or a two-F-1-engine *Saturn* booster by 1967.

Harold B. Finger, director of the joint AEC-NASA nuclear rocket program, told Congress that either vehicle would be capable of boosting NASA's minimum requirement for a 12,300-lb. return payload from the moon. Without a nuclear stage, these vehicles would be able to make a manned lunar landing only through the use of the "rendezvous" space concept.

Mated to a four-F-1-engine *Nova* booster, Finger said, a nuclear third stage would be able to send an *Apollo* spacecraft on a direct flight to the moon with capability of returning a payload of 17,000 lbs.—well over NASA's minimum standard.

Performance with a two-F-1-engine *Saturn C-3* booster would be marginal, but still equal to a direct moon flight.

A nuclear-engine third stage with a thrust of 250,000 to 350,000 lbs. on the *C-3* would have a return capability of only 12,500 lbs.

Both estimates are based on the use of a hydrogen-oxygen return rocket for the *Apollo* spacecraft.

• **Boost for NERVA**—If the upcoming tests are successful, NASA Administrator James E. Webb told the Joint Committee on Atomic Energy, a big boost in *NERVA* funding will be requested in the Fiscal 1963 budget. In Fiscal 1962, combined funding of both AEC and NASA for the project is only $89 million.

He also said that a contractor for the project will be chosen early in 1962. Best bet is that the contract will go to the joint Aerojet-Westinghouse development team. Only an unsatisfactory performance in the team's current six-month development contract would force NASA to look for another contractor.

The principal purpose of the upcoming tests on the Kiwi-B reactor is to determine what materials will be required for the reactor core structure.

The first test in October will be run with gaseous hydrogen as the reactor coolant and propellant. The test next spring will mark the first use of liquid hydrogen.

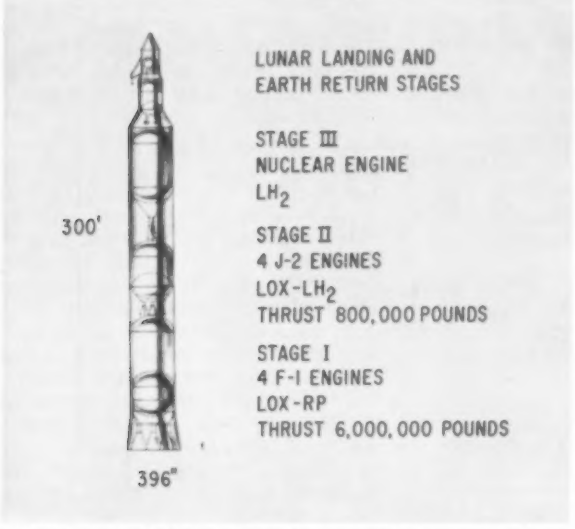
As an example of the seriousness with which NASA views the potential of the nuclear rocket for manned lunar missions, space agency officials said that all of the *Saturn* and *Nova* boosters will be designed so that their upper stages can be modified to use atomic power.

The growth potential of such vehicles was also stressed. This lies principally in the four-F-1-engine *Nova 4*, developing a thrust of six million lbs.

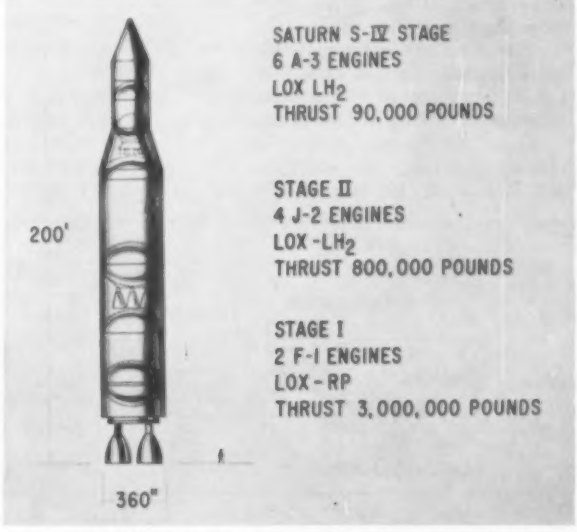
• **Pressing for SNAP**—In another nuclear space application development, officials of Atomics International told the committee that the big problem in the development of *SNAP 10-A*, the 500-watt thermoelectric auxiliary power unit, in Fiscal 1962 is to obtain a thermoelectric power conversion subsystem.

Because of the critical schedule, two parallel concepts are being pursued. One concept utilizes the vacuum of space as the electrical insulator at the cold junction of the thermoelectric elements. This minimizes thermal and electrical losses and direct-couples the thermoelectric converter to the space radiator.

The alternative concept uses a very compact design wherein the thermoelectric elements are made up in annular rings that are stacked one upon another with the reactor coolant passing down the center and a secondary coolant on the outside to carry the heat to the space radiator. ¤

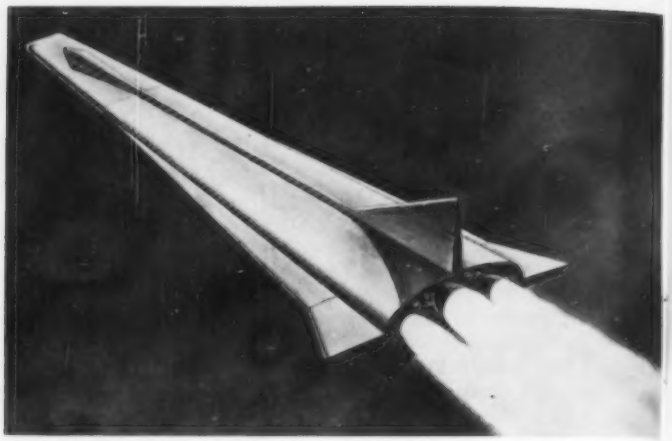


NUCLEAR NOVA 4—Thrust for manned deep-space trips.



NUCLEAR SATURN C-3—Power for direct moon flight.

"ASTROPLANE" would use flex wings for take-off, landing.



LENGTH of craft would protect crew from nuclear reactor.

Using liquid nitrogen . . .

Martin Reveals Nuclear ASP Concept

Elongated craft would have size of B-70 and ability to use present runways; surface would radiate heat energy

DENVER—Design approach to *Aerospace Plane (ASP)* at The Martin Co. calls for eventual use of a nuclear-liquid nitrogen engine, MISSILE AND ROCKETS has learned.

Although admittedly not as efficient as Marquardt Corp.'s LACE (liquid air cycle engine), which employs liquid oxygen and liquid hydrogen, the nuclear monopropellant system is said to offer promise of a smaller vehicle.

The resultant spacecraft would be approximately the size of a B-70, with a full capability of using present-day runways, according to Martin designers.

Dr. Carl Kober, director of advanced technology at Martin-Denver, describes the design, labeled *Astroplane* by the company, as a long-range goal in the firm's advanced programs.

Design sketches (see photos) reveal a lengthy craft, due both to need for extensive tanks for storage of liquid nitrogen scooped from the atmosphere and to use of distance as crew protection from the nuclear reactor. The lifting body concept is employed for reentry, with extendable flex wings for landing and take-off.

Another design factor is use of the vehicle surface as a radiator for dispelling heat energy from the reactor and from the decelerated scooped gases. Since this must be in proportion to the scooping rate, which is determined by altitude and inlet radius, the vehicle will be long with a small cross-sectional area.

It would be capable of scooping up its fuel at altitudes as low as 320,000 ft.

Air Force *ASP* specifications call for a spacecraft capable of taking off from B-52 runways, accelerating to orbital speed and returning to the take-off field. Some eight study contracts now are said to be out on the *ASP* concept. Cost of bringing such a craft to operational status by 1970 has been estimated at from $3-5 billion (M/R, May 29, p. 43).

• **Nitrogen with MHD?**—Some indication of the type of propulsion system which might be applicable is contained in the August issue of *Astronautics*, in an article by Morton Camac and Felix Berner of the Avco-Everett Research Laboratory.

They suggest that nitrogen can be used as propellant in electrical-propulsion systems, such as magnetohydrodynamic (MHD) accelerators of plasma. The authors note that even to balance the drag in an air-scooping vehicle, thrust must be supplied to maintain a constant satellite orbit.

"A portion of the scooped gases, preferably nitrogen, would be used for the propulsive fluid to balance this total resultant drag," they report. "To do this, the exhaust velocity would have to be larger than the satellite velocity—greater than 26,000 fps. Since only an electrical-propulsion system can accelerate gases to this velocity, a large electric powerplant is required. Moreover, it can be shown that an MHD accelerator is the only practical means of achieving the necessary specific impulse, which must be in the range of 1000 to 1800 sec. The MHD system would accelerate nitrogen by electromagnetic forces through a jet nozzle."

Energy source would be nuclear. ⌗

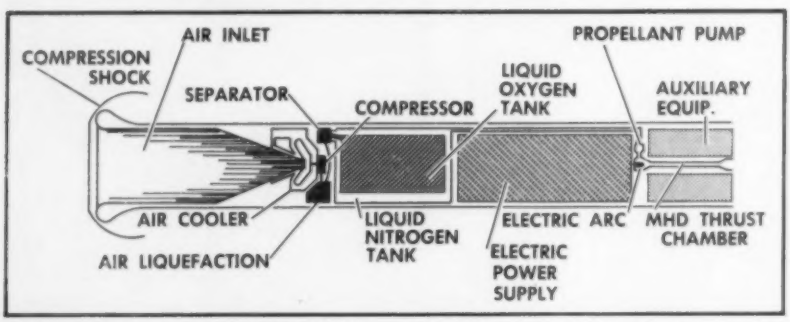


DIAGRAM OF A LIQUID NITROGEN ENGINE based on drawings in Astronautics.

For moon launchings . . .

Cape Expansion to Cost $500 Million

NASA EXPECTS to spend well over $500 million on the just-ordered expansion of Cape Canaveral as a launch site for moon expeditions.

Biggest construction items at the beefed-up facility will be six new launch pads—three for *Saturn C-3* and three for the *Nova* booster, a control and assembly building for the *Saturn C-3*, a blockhouse-type building for *Nova*, a complete cryogenic facility for manufacturing and storing liquid propellants, a building to assemble and check out the *Apollo* spacecraft, special facilities for dynamic testing, and a bio-medical building to house moon expedition crews. In addition, there will be a whole host of minor support buildings.

Construction and preparation of sites will begin this spring with perhaps the heaviest expenditure of funds to come in Fiscal 1963. All of the construction will be completed and ready for use by 1966.

Some $60 million of the half-billion-dollar layout will go to purchase of land.

• **New prosperity**—The expansion of Cape Canaveral will prove a real boon to the surrounding Florida area. More than 5000 NASA and industry employees will be added to the Cape's payroll, which now totals 1200.

Physically, the Cape launch site will be increased by five times its present size—to a total area of 100,000 acres, 25 miles long and 10 miles wide at its broadest point.

NASA officials said that final specifications for new buildings and the launch pads may be delayed as much as several months because of pending decisions concerning the size of boosters and other aspects of the *Apollo* program. They did, however, release the following details:

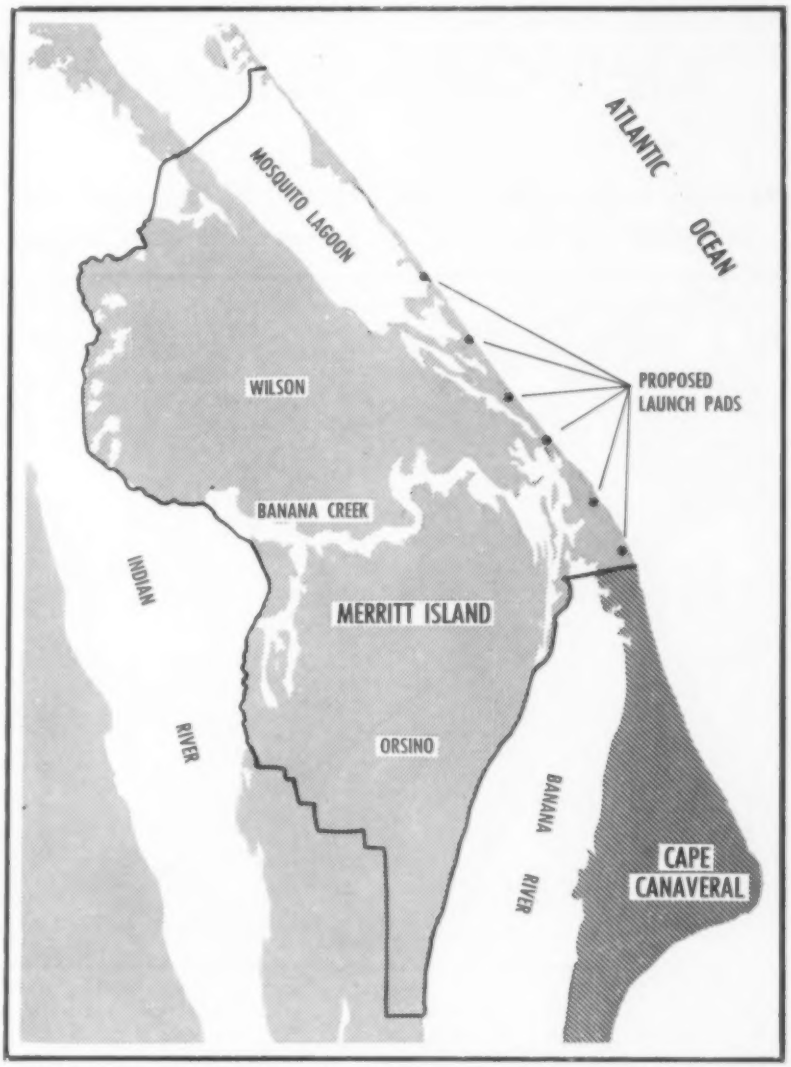
• **Launch Pads**—At least six will be built, but there is room for more. The pads will be built along a 20-mile strip north of the present boundary of the Cape.

The *Saturn C-3* pads — of which there will be three and perhaps more if the space agency decides to use the "space rendezvous" concept for moon missions—will have practically no gantry. Instead, each pad probably will have a simple umbilical mast which will be used in part to get astronauts in and out of the *Apollo* spacecraft. The lack of complex facilities stems from the fact that the *C-3* will not be assembled on the pad but instead will be put together in a building about a mile away.

The *Nova* pads will be monstrous. Gantries will be 500 feet tall and have built-in capacity of withstanding 60-knot winds. Because of the size of the gantry, the space agency still has no definite way of getting it out of the way before the booster is launched. Proposals being studied include hinging it so that it can be bent backward, flying the bird out through the gantry (similar to the *Minuteman* "silo" concept), and splitting the gantry into two halves, so that each side can be moved back slightly.

• **Vertical Assembly Slant Control Building**—This will be used to control the assembly and launching of the *Saturn C-3* booster. As a result, it will have the tallest room in the world—with a ceiling of 400 ft.—where the *Saturn* vehicle will be assembled in a

(Continued on page 44)

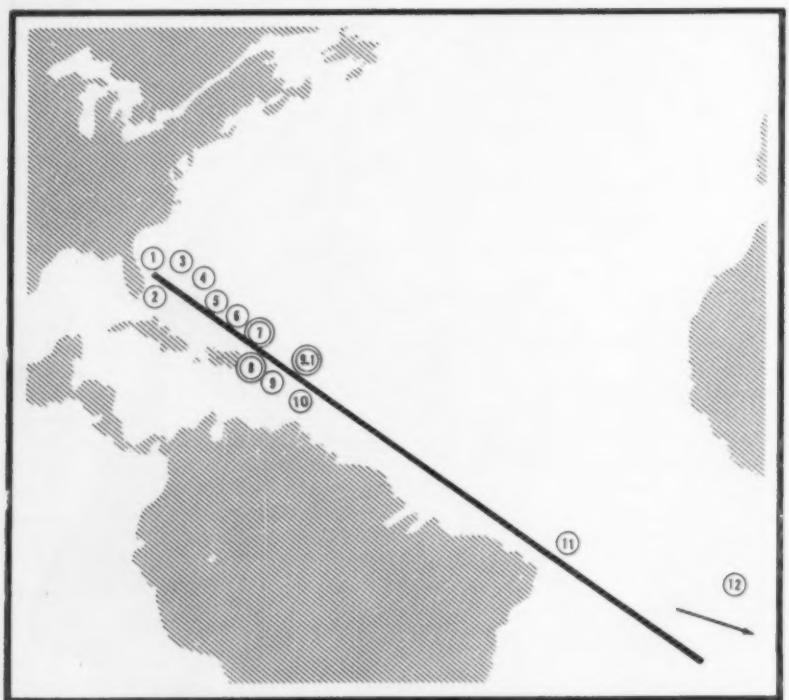


HEAVY DARK LINES indicate boundary of expanded Canaveral launch facilities. Saturn C-3 and Nova pads will be located along 20-mile strip of coast.

To be ready in '63 . . .

AMR Cable Extension Will Bypass the D

New role as terminus of northern part of range will add to importance of Antigua, also monitor of Polaris impacts



DOWNRANGE STATIONS are now tied by underwater cable from Cape Canaveral (1) to Mayaguez, P.R. (9) via Dominican Republic (8). New cable extension will run from Grand Turk (7) through Mayaguez to Antigua (9.1), bypassing Dominica. Other stations: (2) Jupiter; (3) Grand Bahama; (4) Eleuthera; (5) San Salvador; (6) Mayaguana; (10) St. Lucia; (11) Fernando de Noronha. Ascension (12) and Pretoria (13) are not on map.

THE CURRENT EXTENSION of the underwater cable that links Cape Canaveral with most of the upper half of the Atlantic Missile Range will enable the Air Force to avoid possible future political problems in the troubled Dominican Republic.

The important cable, which carries radar data, real-time telemetry and administrative traffic, now extends from the Cape of Mayaguez in Puerto Rico via a relay station near the Dominican Republic town of Sabana de la Mar.

The cable extension will run from Grand Turk Island directly to Mayaguez, skirting the Dominican Republic, and continue on to the Island of Antigua, British West Indies.

The Air Force awarded a $5-million contract last June to the U.S. Underseas Cable Corp. to lay the cable and underwater relay stations. Station equipment is being procured from the West German firm of Felton & Guilleaume. The work is expected to be completed in about two years.

Completion of the extension will enable the Air Force to close its station near Sabana de la Mar, which some officials felt was vulnerable during the political troubles in Dominica this summer and could be again.

• **Double duty**—Extension of the cable to Antigua considerably enhances the importance of the already important island as a downrange station. Antigua not only is the key link at the end of the upper range but also has been the monitoring point for the impact of

LEFT: *Antigua Auxiliary AFB, or Downrange Tracking Station 9.1, is spread over some 280 acres of Island of Antigua, largest of Leeward Islands in the Caribbean.*

RIGHT: *Main dish of Air Force tracking station on Antigua. The station is "up" for a launching on an average of three to four times a week; the rest of the time is spent in maintenance.*

Dominican Republic

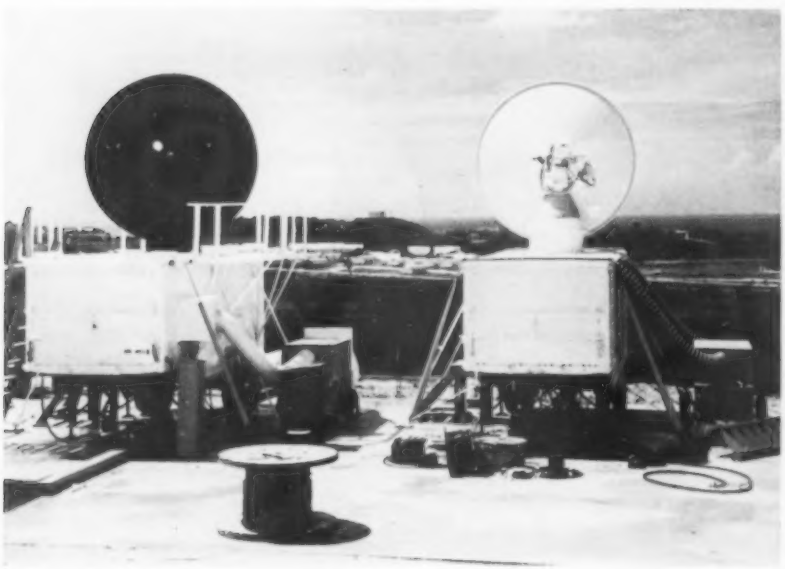
Polaris missiles launched from the Cape.

The island tracking station—1250 miles from the Cape—is manned by one Air Force officer and about 130 civilians. About 60 of the civilians are employed by Pan American; the remaining 70 by RCA.

Civilians receive a 30% bonus for working on the island. Their average tour of duty ranges from about 6 months to three years or longer. Civilians without dependents on the island live and eat at the station. Room and board is provided as part of their contract.

The station—situated on a long-abandoned U.S. Army base—was set up in 1957. Permanent construction was completed in 1959.

A U.S. Naval Oceanographic Station on the island maintains the MILS bull's-eye nearby in the Caribbean for *Polaris* tests. The station is manned by about 100 officers and men. ¤



MOBILE ANTENNAS are emplaced on top of hill overlooking base and Naval Oceanographic Station that operates the "bull's-eye" for Polaris tests.

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Technical Countdown

ASTRONAUTICS

Earth-Venus Distance Further Refined

Using advanced radar astronomy techniques, RCA scientists have reportedly succeeded in determining the distance between earth and Venus to an accuracy of 200 miles in the 30-million-mile span. An 84-ft. radar tracking antenna—designed and developed for RCA by Goodyear—bounced beams of radio energy off Venus and determined the pattern of the returning echoes with the assistance of a high-speed computer which made six billion calculations of the incoming data.

Limitations on Lunar Launch

A report recently released by NASA's Lewis Research Center outlines some of the limitations on direct launches from the earth's surface to the moon. In describing the mission, the report notes that the booster may travel as much as 30° to 40° down range, causing a shift in the burnout latitude which may seriously increase the energy required for the flight. To compensate for this and other anomalies, reasonably low-energy trips may be made only during the first half of the lunar nodical month—and even during this period many days will be unsuitable, since the flight paths may pass over populated areas.

Bowling Ball Scores Space Strike

An ordinary bowling ball helped Lockheed engineers solve the problem of returning a *Discoverer* data capsule from space. Used as an air-cushioned bearing, the bowling ball enabled the engineers to test a new spin stabilization system for the *Discoverer XIII* capsule, which later was recovered from orbit.

SPACE MEDICINE

Space Hypnosis

A survey is being conducted to seek out specific ways in which a cosmonaut may use hypnosis to adjust to space travel. Dr. H. McCord, University of Colorado, is contacting leading psychologists and physicians all over the world.

High Flying Quails

Quail eggs and fruit flies hitched a 40-mile ride on a Navy weather rocket launched from Point Mugu in a three-way experiment designed to investigate the weather study effect of radiation on the specimens, and check out the specimen capsule. The eggs will be hatched and the flies bred to determine the effects, if any.

Solar Food Warmers

Astronauts flying through space may have hot meals warmed by the sun. A solar stove developed by REF Manufacturing Corp. for the Air Force consists of a magnesium plate for collecting solar energy and an integral half-cavity to hold three food containers. A warmer door mounted on slotted hinges aligns the magnesium plates and incorporates three face-mounted thermometers to measure the individual food cavity temperatures.

Grass in Space Ships

Martin Co. Biochemist E. W. Chappelle has found that green plants will protect future astronauts from the deadly effects of carbon monoxide produced by the ship's electrical system, fuel combustion and the pilots themselves. Chappelle is investigating the mechanisms involved which convert the monoxide to the dioxide. His findings so far show the reaction to be universal, requiring only oxygen and independent of light.

ELECTRONICS

Electrical Balance for Gyros

A device to balance gyros by inducing electrically the right amount of compensating torque has been patented by E. J. Mullarkey, president of Avcon Corp. The device—called a Mass Shift Compensator—functions as an electrolytic cell with two equal masses of metal aligned at opposite ends of a small glass cylinder filled with a suitable electrolyte. Depending on the polarity of the d-c current, molecules of metal deposit themselves on one end or the other of the tube. As the relative mass of the electrodes changes, a compensating torque is induced and the gyro brought back into balance.

Apollo Guidance 'Outs'?

Selection by NASA of the Massachusetts Institute of Technology to develop the guidance system for *Apollo* is a bitter blow to many leading guidance manufacturers. Dr. C. Stark Draper's almost contemptuous opinion of two-degree-of-freedom-gyro systems, say industry observers, will serve as an insurmountable barrier for those companies who have taken that approach in their missile guidance development. Companies who may feel they are already out of the running include: Autonetics, Arma, Bell Aerospace, and Litton. M.I.T. has been directly associated with guidance system design and development for *Polaris A-1*, *A-2*, *A-3*, *Thor* and *Titan II*. All employ single-degree-of-freedom gyros.

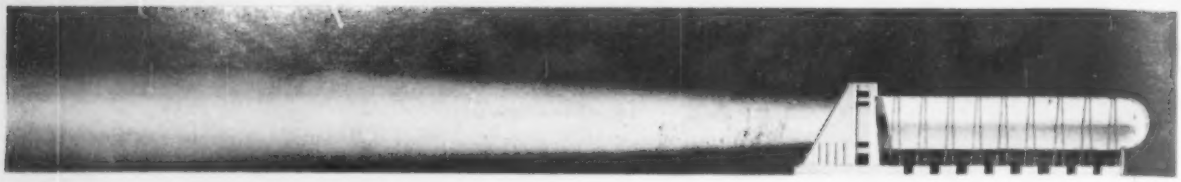
ADVANCED MATERIALS

Gold-plated Teflon

Continuous thin films of gold covering the inside of the bladders in positive fuel-expulsion systems will increase the fuel-holding efficiency of the units. Chemically deposited gold reduces the permeability of teflon to some high-energy fuels by as much as 10 to 1000 times. Quantum Inc., a research firm, and Joclin Manufacturing Co., producers of fuel bladders, cooperated in the discovery.

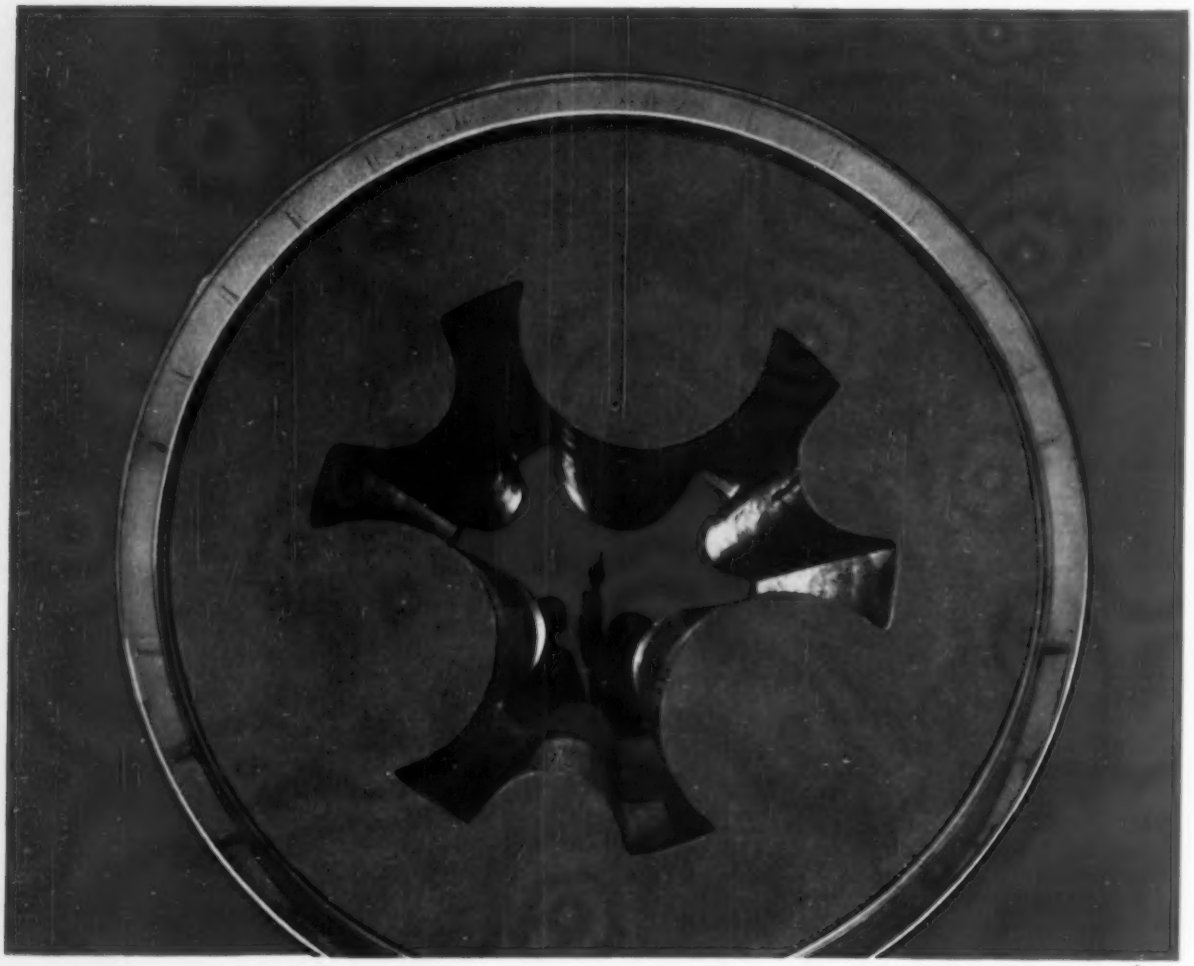
Two New Space Chambers

Chicago Bridge & Iron Co. engineers are working with an 8 by 18-ft. vacuum chamber capable of reaching pressures down to 5×10^{-7} mm Hg. Lower ultimate pressures will be attainable with the addition of a cryogenic trapping system. The unit is currently being used in the Grumman *Orbiting Astronomical Observatory (OAO)* project. . . . GE's Missile and Space Vehicle Dept. has reported that a low pressure of 3×10^{-7} mm of mercury was achieved with diffusion pumps alone during checkout of their space simulator at the Valley Forge Space Technology Center. With the installation of cryogenic panels this fall, pressure levels of 10^{-9} mm of mercury should be possible.



AEROJET FIRES WORLD'S LARGEST SOLID ROCKET

This segmented solid rocket booster developed far more energy than ever before achieved in solid rocket technology, surpassing the previous largest booster fired, also an Aerojet-General motor. Built and tested by Aerojet-General for the Air Force, this flight-weight segmented motor, combined with more of the same units, could launch a three-man orbital flight. The success of this firing, at a thrust level of approximately a half million pounds, confirms Aerojet's technical ability to scale up and produce *reliable, low-cost* solid propellant boosters for lifting large payloads into space.



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Nimbus Will Carry PCM Telemetry

First satellite system to use PCM will benefit most from its low power demands; Radiation, Inc., wins award

by James Trainor

NIMBUS—NASA's follow-on program to the highly successful *Tiros* meteorological satellite—will be the first satellite system to use Pulse Code Modulation (PCM) telemetry.

Details of the spacecraft PCM system were revealed recently in an announcement of a contract award to Radiation, Inc., for the ground and space vehicle telemetry systems.

An advanced weather satellite, the first *Nimbus* vehicle is expected to be launched into a 600-mile, polar orbit about the middle of next year. Although designed as a transitional system until the 24-hour *Aeros* satellite system is developed, *Nimbus* will represent a marked improvement over *Tiros* by providing complete global coverage due to its earth stabilization and polar orbit.

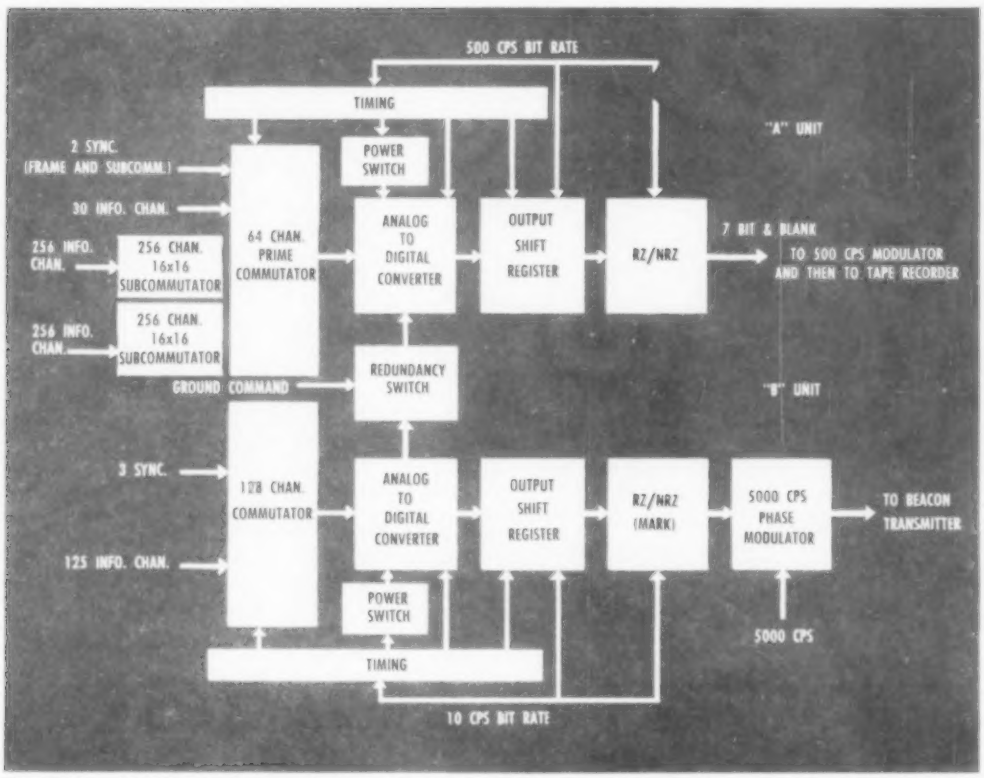
• **PCM system**—Each *Nimbus* spacecraft will carry two electrically independent PCM systems weighing less than 30 lbs. and consuming only 1.4 watts of power. Both systems will be located in a pie-shaped segment of the satellite's circular body. The first system (Unit A) continuously stores data on tape for command readout and is capable of handling some 540 channels, while the second system (Unit B) delivers 128 channels by direct transmission.

The ground stations receive and process the data transmitted from the satellite and, by visual displays, allow an immediate review of the cloud picture information gathered over much of the globe. In addition, the PCM ground system can present visual displays of selected data on an oscillograph for an immediate look at information as it is actually being received.

• **Low-power advantages**—Probably the greatest advantage of the *Nimbus* PCM system is the low power requirement for the satellite-borne packages. Simplifying the circuitry and reducing the number of transistor devices for each gate has reduced the power drain by the multiplexer substantially.

The total power requirement — 1.4 watts for both systems—enables a reduction in the number of solar cells and, consequently, the total vehicle weight. The resultant power savings are estimated at 30-1 over present systems.

• **PCM system details**—The telemetering subsystem accepts information from all the satellite "housekeeping" subsystems as well as from the low-rate data sources and scientific experiments aboard the vehicle. Information of the yes-no type or in analog signal form is stored by the A unit for command readout, or directly transmitted by the B unit upon interro-



NIMBUS, scheduled to be launched in late 1962, will be first U.S. spacecraft to use PCM telemetry.

gation. During the operation of the B unit, the A unit is turned off.

The A unit—consisting of a seven-bit analog-to-digital converter, a 540-channel multiplexer, subcommutator, gates and registers—employs less than one watt of continuous power for monitoring the data channels and for continuously checking the performance of such things as the attitude control systems, gyroscopes and radiometers. These channels are time-multiplexed and serially recorded upon tape at a bit rate of 500 cps for playback at 15,000 cps—a 30-1 ratio of time compression.

The unit's coder, similar to that used in the B unit for redundancy, accepts unsymmetric inputs from zero to minus 6.4 volts with a channel input impedance of 100,000 ohms.

• **B Unit operation**—Operating only upon ground command, the second PCM unit uses less than four-tenths of a watt operating power to scan 128 channels of less critical data at slow speed for a 1.75-minute reporting period. This enables ground stations to obtain several scanning sequences during the 18 minutes in which the satellite is within range.

The B unit consists of an analog-to-digital converter similar to that of the A unit, a multiplexer, gates and a phase shift modulator. Employing a bit rate of 10 bits/second with a maximum of 128 words, the direct unit includes synchronization with three words in the form of all "ones" followed by all "zeros" followed by all ones."

Both units are controlled by separate clocks located in another subsystem. These clocks furnish 500 cps to the A unit and 10 cps to the B unit in the form of 1 volt peak-to-peak square waves.

• **High reliability guaranteed**—In general, the system components operate at power levels below the maximums prescribed by the specifications and, therefore, contribute to the reduction of potentially destructive internal heat. Other factors which increase the system reliability include: system and circuit redundancy, careful parts selection, exhaustive testing of circuits and components, and special environmental packaging.

To further guarantee the system's reliability, the coder modules in both the A and B units can function in place of each other automatically or upon ground command. Parallel and in some cases quadruple circuity has been designed into the system to increase reliability in vital areas.

• **Rugged testing planned**—To realize the system's required design life of a minimum of six months in orbit, a comprehensive testing program has been planned for the satellite-borne telemetry packages. The rugged environmental tests of the PCM systems will be conducted for long durations in a vacuum of 10^{-5} mm of mercury. A temperature-altitude cycling test between 0°-55°C is to be conducted for a period of 13 days operating time. Sinusoidal and random wave vibration tests will also be run for accelerations of 10 and 20 gs, respectively. The effects of a 30-g linear acceleration that the system might experience on launch will also be studied.

• **Future developments**—Although the PCM system for *Nimbus* is the first such satellite telemetry system, Radiation, Inc., has indicated that a second PCM system to be used with a communications satellite will soon be announced. Under the *Nimbus* pact, Radiation will design, develop and fabricate seven complete systems—two prototypes and five flight models.

NASA's Goddard Space Flight Center at Greenbelt, Md., will manage the contract. In addition to Radiation, the *Nimbus* contractors include: General Electric's Missile and Space Vehicle Dept. (integration, test and stabilization), RCA Astro-Electronics (cameras and solar power systems) and IT&T Laboratories and Santa Barbara Research Center (infrared equipment). ⁂

SCHEMATIC SHOWS PCM telemetry packages, consisting of two main units, for Nimbus. These units greatly enhance weather data gathering and transmission.

Dyna-Soar type Vehicles Urged for Navy A-ICBM Use

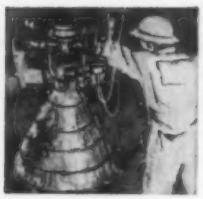
THE NAVY is considering use of *Dyna-Soar*-type vehicles launched from aircraft carriers to protect its surface vessels against attack by ICBM's.

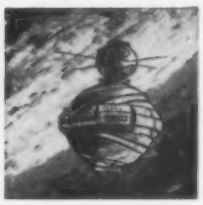
The manned boost-glide approach has been proposed as a part of fleet air defense by McDonnell Aircraft, which is conducting an in-house study of the concept. It was described at a classified session of the IAS/Naval Aviation meeting in Los Angeles by John Aldridge, McDonnell vice president/advanced projects.

The advanced concept is entirely feasible, Aldridge said, and the powerplant is "almost within the state of the art," or within the 1970 time period. He noted that the boost-glide craft would have quick reaction time and could loiter for extended lengths of time several hundred miles away from the heart of a task force.

The Navy's only present defense against ICBM's is its "three T's"—*Terrier*, *Tartar* and *Talos*. All of these have limited tracking ability. The *Typhon* system now under development will have improved tracking.

An anti-satellite system for the Navy is being studied by Chance Vought, company Vice President W. P. Thayer disclosed. He said the proposal calls for a sea-launched system which could be used for surveillance of orbiting satellites or a defense against other threats from space, more economically and effectively than airborne platforms.





SEPTEMBER, 1961

MISSILES and ROCKETS

ASTROLOG

Current status of U. S. missile and space programs plus all orbiting satellites

Satellites and Spacecraft

PROJECT	CONTRACTORS	DESCRIPTION	STATUS
ADVENT (Army)	Army Signal Corps, prime; Bendix prime for 24-hour satellite communications package; GE, vehicle	Twenty-four hour instantaneous repeater communications satellite; more than 1250 lbs.; program incorporates Projects STEER, DECREE and COURIER	R&D; ground sites to be equipped at Ft. Dix, N.J., and Camp Roberts, Calif.; shipboard terminals also being designed; first ATLAS-CENTAUR launchings late '62; may use TITAN II space booster
ANNA (Army, Navy, AF, NASA)	No contractors announced	Geodetic satellite; 50-100 lbs.; probably spherical	Study completed; R&D program appears imminent
AEROS (NASA)	No contract announced	24-hour weather satellite to be boosted by CENTAUR	Planning. First flights would be in 1964 or 1965; unfunded FY '62 budget; TV camera R&D to begin soon
★**APOLLO** (NASA)	MIT, guidance	Three-man spacecraft capable of orbiting moon or becoming space station; probably winged for lunar flights; boosted by SATURN	Convair, GE, Martin studies completed; spacecraft bids for accelerated program due Oct. 9; awards due by year-end
ARENTS (ARPA)	Convair, prime	Satellites to investigate deep space; 22,000 n. orbits; ATLAS-CENTAUR booster	Contract let to build three payloads; launchings begin early '62
ASP (Air Force)	No contracts announced	Aerospace plane, a manned spacecraft capable of operating in the atmosphere and space	Study
BAMBI (ARPA)	Convair, STL	Satellite system capable of intercepting enemy missiles in boost phase	Studies
CSAR (Air Force)	No contracts announced	Communications satellite system; satellites to weigh possibly two tons; to use passive lens reflectors	Studies; possibly operational mid-60's
★**DISCOVERER** (Air Force)	Lockheed, prime; GE, re-entry vehicle	THOR-AGENA and ATLAS-AGENA launchings of early stabilized satellites; main purpose is to test techniques for military space systems	Launchings: 28; 6 capsules recovered from orbit (4 air-snatched) after orbiting earth one to three days; plans to put simians in capsules scrapped.
★**DYNA-SOAR I** (Air Force)	Boeing, spacecraft and systems integrator; Martin, propulsion; Minneapolis-Honeywell, guidance; RCA, communications data link	Boost-glide orbital spacecraft; R&D leading to first space bomber; TITAN II booster; 3rd powered stage to be added	R&D; first glider flights from Edwards AFB 1962; R&D suborbital flight about early 1965; program accelerated somewhat under FY '62 budget; further acceleration under consideration
ECHO (NASA)	Langley Research Center, prime	ECHO I: 100 ft. inflatable sphere in 1000 mile orbit; passive communication satellite; ECHO II: 135-ft., 700-mi. orbit	In orbit since Aug. 12, 1960; ECHO II scheduled to be launched 1962; suborbital tests late '61

★ Indicates changes since July, 1961, Astrolog

PROJECT	CONTRACTORS	DESCRIPTION	STATUS
MARINER (NASA)	JPL, prime	600-1200 lb. unmanned spacecraft for early interplanetary missions; boosted by ATLAS-AGENA B	Seven shots planned. First scheduled Venus fly-by Aug. 1962
★**MERCURY** (NASA)	McDonnell, capsule	First U.S. manned satellite; 4000 lbs. + (capsule including escape rocket)	First manned orbit shot expected late 1961 or early 1962. Sub-orbited launchings with REDSTONE ended after two successes; at least two orbital shots (one with simian), to precede manned shot
★**MIDAS** (Air Force)	Lockheed, prime; Aerojet, IR detector system	Early-warning satellite; detect ICBM launchings by IR before birds leave pad; R&D models weigh 2.5 tons; operational system 12-15 satellites	R&D; second launching May 24, 1960 partial success; MIDAS III successfully launched July 12, components being tested by DISCOVERER
NIMBUS (NASA)	GE, prime	2nd generation weather satellite; 650 lbs.; 6 TV cameras in payload; THOR-AGENA B booster	First launching scheduled for late 1962
OAO (NASA)	Grumman, prime; Westinghouse, electronic components; GE, stabilization and control	3500-lb. orbiting astronomical satellite observatory equipped with telescope; boosted by ATLAS-AGENA B	First flight scheduled in late 1963 or 1964
OGO (NASA)	Space Technology Laboratories, prime	1000-lb. satellites with instruments for geophysical measurements; polar (POGO) and eccentric (EGO) shots planned; ATLAS-AGENA B, THOR-AGENA B, CENTAUR boosters	First flight scheduled in 1963
★**OSO** (NASA)	Ball Brothers, prime	440-lb. orbiting solar observatory; THOR-DELTA booster; S-16	First flight planned this fall for S-16; first flight for S-17 planned for 1962
PROSPECTOR (NASA)	No contract announced	Soft-landed, remote control, unmanned moon exploring spacecraft; SATURN booster	First flight planned by 1965; study contracts to be awarded in 1961
★**RANGER** (NASA)	JPL, prime; Aeronutronic, capsule; Hercules, retrorocket	300-lb. instrumented capsule rough landed on moon; ATLAS-AGENA B booster	R&D; first flight Aug. 23, RANGER failed to launch from orbit; next shot Oct.; first lunar landing planned for 1962.
REBOUND (NASA)	No contract announced	System of 3 to 6 multi-launched ECHO II communications satellites	First orbital flight scheduled for 1963 or 1964
★**RELAY** (NASA)	RCA, prime	100-lb. active repeater communications satellites. Commercial system planned; DELTA launched	Both Britain and France to take part in program; Latin American interest sought; first launching next year
SAINT (Air Force)	RCA, prime	Anti-satellite satellite inspection system; to be complemented by interception system; about 2 tons; ATLAS launched	R&D underway; to be launched against reflectors or balloons in 400-mi. orbits late '61
★**SAMOS** (Air Force)	Lockheed, prime	Reconnaissance satellite; formerly SENTRY; R&D model weighs 4100 lbs.	R&D; SAMOS II successfully launched Jan. 31 from Vandenberg; scheduled to be operational late 1962; components being tested in DISCOVERERS; advanced SAMOS under development
SLOMAR (Air Force)	Lockheed and Martin, prime	Logistics, maintenance, supply spacecraft for space systems	Study contracts awarded in December
SURVEYOR (NASA)	Hughes, prime	750-lb. spacecraft soft-landing 100-300 lbs. instruments on moon; ATLAS-CENTAUR booster	First moon flights 1963; seven or more to be launched by 1965
SYNCOM (NASA)	Hughes, prime	24-hr. instantaneous repeater communications satellite.	R&D; first launching scheduled late 1962
★**TIROS** (NASA-AF-Army-Navy-Wea. Bu.)	RCA-Army Signal Corps, prime	Meteorological satellite; TV pictures of cloud cover; TIROS II carried IR scanner	R&D; first launching last April; second Nov. 23; third July 12, all successful; two more planned
★**TRANSIT** (Navy)	Applied Physics Laboratory, prime	Navigational satellite; R&D model weighs more than 250 lbs.; operational model about 50-100 lbs.	TRANSIT IB R&D satellite in orbit April 13, 1960; IIA plus piggyback satellite in orbit June 22; TRANSIT IIIB launched into poor orbit Feb. 21; IVA orbited June 29 with 2 piggy-back payloads that failed to separate; 4-satellite system scheduled to be in orbit 1962
VOYAGER (NASA)	No contract announced	Unmanned spacecraft to orbit Mars or Venus; eject capsule for re-entry; SATURN booster	Study; first flight planned by 1965
YO YO (Navy)	No contract announced	Tactical sea-launched one-pass reconnaissance satelloid	R&D
X-15 (NASA-AF-Navy)	North American, prime; Thiokol, propulsion	Rocket plane; 4000 mph; flight at edge of space; on AF model each XLR-11 rocket engine develops 16,000 lbs. of thrust; XLR-99 engines 50,000 lbs. Three planes delivered.	Powered flights in progress; plane #1 has hit Mach 3 and more than 136,500 ft. with XLR-11 engine; plane #2 with XLR-99 engine turned over to NASA; has hit 3690 mph speed record; altitude record of 169,600 ft. (unofficial for manned, powered flight)

Missiles and Rockets

PROJECT	CONTRACTORS	DESCRIPTION	STATUS
ALFA (Navy)	Navy, prime; Avco, air frame	ASW surface-to-underwater; 500 lb. solid; conventional	Deployed on destroyer escorts
ARM (Navy)	No contract announced	Anti-radar missile; air to surface	R&D; AF anti-radar missile by same name at least temporarily shelved
ASROC (Navy)	Minneapolis-Honeywell, prime; Sangamo Electric, sonar; torpedo, GE; depth charge, M-H	Surface-to-underwater; solid rocket torpedo or depth charge; nuclear or conventional, range about 8 miles; advanced ASROC (improved Mark 44 torpedo) under R&D	Operational on Destroyers Norfolk, Adams, Dewey and Perry; plans call for deploying on 150 destroyers and cruisers
ASTOR (Navy)	Westinghouse, prime	ASW underwater to underwater rocket torpedo; nuclear	R&D
★**ATLAS** (Air Force)	Convair, prime; GE/Burroughs, Arma, guidance; Rocketdyne, propulsion; GE/Avco, re-entry vehicle	ICBM; more than 5500-to-7500 mile range; liquid; nuclear; ATLAS "E" series has inertial guidance; earlier ATLAS "D" has radio inertial; proposed ATLAS "G" would have 900,000-lb. thrust and 4000-lb. payload capability	93 launchings; 62 successes, 21 partial, 10 failures; 11 bases for 13 squadrons; operational at Vandenberg and Warren; ATLAS E tests began Oct. 11; about 18 to 21 launchers operational—40 to 60 expected in 1961. First successful "E" shot Feb. 24
BOMARC-A (Air Force)	Boeing, prime; IBM/Westinghouse, guidance; Aerojet/Marquardt, propulsion	Ramjet surface-to-air interceptor; liquid booster; 250 m. range; Mach 2.7; nuclear	Five bases operational in Northeastern U.S. from Virginia to Maine
★**BOMARC-B** (Air Force)	Boeing, prime; Kearfott/Westinghouse, IBM Guidance; Thiokol/Marquardt, propulsion	Ramjet, surface-to-air; solid booster; Mach 2.7; more than 400 m. range; nuclear	Operational; a B test bird intercepted simulated target 345 miles away Oct. 14; being deployed at 6 U.S. bases, two in Canada
BULLPUP (Navy-Air Force)	Martin, prime; Martin, guidance; Thiokol, Naval Propellant Plant, propulsion; Maxson, second-source prime	Air-to-surface; 3-6 mile range; conventional 250-1000-lb. bomb; new model has pre-packaged liquid; nuclear-tipped model nearly operational; AF designation: GAM 83-A (HE warhead), GAM 83-B (nuclear)	Deployed with Atlantic and Pacific Fleets; bigger model under R&D; soon operational with Air Force units. Marines launching BULLPUP from helicopters
COBRA (Navy)	No contract announced	Anti-ship radar missile	Early R&D
COBRA (Marines)	Boelkow Entwicklungen, West Germany, prime manufacturer; Daystrom, U.S. licensee	20.2-pound anti-tank missile; 1 mile range; 191 mph speed; solid propellant	Marines planning to purchase; Army considering them; already operational with West German troops
CORPORAL (Army)	Firestone, prime; Gilfillan, guidance; Ryan, propulsion	Surface-to-surface; 75-mile range; liquid; nuclear	Deployed with U.S. & NATO troops in Europe
CROW (Navy)	No contract announced	Air-to-air missile	R&D; has been flight tested
DAVY CROCKETT (Army)	In-house project directed by Rock Island, Ill., arsenal	Surface-to-surface; solid; bazooka launched; sub-kiloton nuclear warhead; two launchers of different size for various ranges; vehicle mounted or carried by two men	Late R&D; deployment delayed until 1962
ENTAC (Army)	Nord Aviation, prime	Anti-tank; 6600-ft. range; 37 lbs.; HE warhead; wire-guided.	Operational; Army buying from French in quantity
FABMIDS (Army)	Convair, Hughes, Martin, GE, Raytheon, Sylvania—feasibility studies	Mobile anti-missile defense system	Each of six contractors have $250,000 feasibility study contracts awarded Oct. 10; reports expected mid-'61
★**FALCON** (Air Force)	Hughes, prime; Hughes, guidance; Thiokol, propulsion	Air-to-air; 5-mile range; Mach 2; solid; conventional; GAR-11 model has nuclear warhead	Operational; buy-out of GAR 3A, 4A and 11 in FY '62
GENIE (Air Force)	Douglas, prime; Aerojet-General, propulsion	Air-to-air unguided; 1.5-mile range; nuclear	Operational
GIMLET (Navy)	No contract announced	Air-to-surface; unguided; considered highly accurate	R&D
★**HAWK** (Army)	Raytheon, prime; Raytheon, guidance; Aerojet-General, propulsion	Surface-to-air; 22-mile range; solid; conventional; designed to hit low-flying planes	Operational; deployed in Europe, Panama, Okinawa, U.S. (13 battalions), SUPER HAWK under development; Jan. 29, 1960 successfully intercepted HONEST JOHN, first known missile intercept of another

PROJECT	CONTRACTORS	DESCRIPTION	STATUS
★**HONEST JOHN** (Army)	Douglas/Emerson Electric, prime; Hercules, propulsion	Surface-to-surface; unguided; 12-mile range; nuclear; 5800 lbs.; ADVANCED HONEST JOHN has increased performance, lighter	Operational; deployed in Europe
HOUND DOG (Air Force)	North American, prime; Autonetics, guidance; Pratt and Whitney, propulsion	Air breathing air-to-surface; 500-mile range; Mach 1.7; turbojet; nuclear	Operational; to be launched from B-52G intercontinental bombers; stockpile expected to exceed 400
★**JUPITER** (Army)	Chrysler, prime; Ford Instrument, guidance; Rocketdyne, propulsion; Goodyear/CTL, re-entry vehicle	IRBM; liquid; nuclear; can be made mobile	Operational in Italy (30 launchers) with Italian AF; being deployed in Turkey; 32 military launchings: 25 successes; 5 partials; 2 failures. Full tactical GSE used for first time in Oct. 20 shot from Cape.
LACROSSE (Army)	Martin, prime; Martin, guidance; Thiokol, propulsion	Surface-to-surface; highly mobile; 20-mile range; solid; nuclear	Operational; three units deployed in Europe; more being trained; advanced LACROSSE R&D dropped
LAW (Army)	Hesse-Eastern Div., Flightex Fabrics, prime	Light anti-tank rocket; carrier tube launcher; 4.5 lbs.; 25 in. long/3 in. diameter	R&D under AOMC
LITTLE JOHN (Army)	Emerson Electric, prime; Hercules Powder, propulsion	Surface-to-surface; unguided; 10-mile range; solid; nuclear	First 4-launcher battalion operational this winter
LOBBER (Army)	No contract announced	Surface-to-surface; cargo carrier; 10-15 mile range; also can drop napalm; LOBBER with warhead called BALLISTA	Studies
LULU (Navy)	General Mills/Naval Ordnance Lab, prime	Small nuclear depth charge air-dropped or launched by ASROC	Operational
MACE (Air Force)	Martin, prime; Goodyear/AC Spark Plug, guidance; Thiokol/Allison, propulsion	Air-breathing surface-to-surface; more than 650-mile range; turbojet & solid-nuclear; B model has more than 1200 mile range	Being deployed with U.S. troops in West Germany; now all mobile but hard-base version development completed; to be in Okinawa, Korea
MATADOR (Air Force)	Martin, prime; Thiokol/Allison, propulsion	Air-breathing surface-to-surface; 650 mile range	Being turned over to West Germans; also deployed in Far East
MAULER (Army)	Convair, prime	Surface-to-air; radar guidance; highly mobile antiaircraft and antimissile missile for field use; on tracked vehicle; 12 missiles per launcher	R&D; NATO may buy
★**MINUTEMAN** (Air Force)	Boeing, major contractor; Autonetics, guidance; Thiokol, propulsion first stage; Aerojet, propulsion second stage; Hercules, third stage; Avco, re-entry vehicle; AMF-ACF, rail launcher	2nd generation ICBM; solid; fixed or mobile aboard railroad trains; nuclear; 3 stages	R&D; scheduled to be operational mid-1962 at Malmstrom AFB; 3 Launchings: 2 successful, 1 partial; tactical rail system tests completed; 3 squadrons at Malmstrom, Mont.; Ellsworth, S. D.; Whiteman, Mo.; Minot, N. D. 12 fixed squadrons now planned; mobile system indefinitely postponed
M-55 (Army)	Norris Thermador, prime	Four-inch diameter, small, short-range poison gas rockets; to be fired from 45-tube launchers	Operational
MISSILE A (Army)	ARGMA, prime	Surface-to-surface; 10-20 mile range; solid	Design studies
★**MISSILE B** (Army)	No contractors announced	A highly mobile general purpose missile; range 30-50 miles.	Study
NIKE-AJAX (Army)	Western Electric, prime; Western Electric, guidance; Thiokol, propulsion; Douglas, airframe	Surface-to-air; 25-mile range; Mach 2.5; solid & liquid; conventional	Deployed in U.S., Europe & Far East; about 170 batteries in U.S., sixty-eight more to be phased out and replaced with NIKE-HERCULES
NIKE-HERCULES (Army)	Western Electric, prime; Western Electric, guidance; Hercules & Thiokol, propulsion; Douglas, airframe	Surface-to-air; 75-mile range; Mach 3+; nuclear; anti-aircraft, tactical missiles; mobile or fixed	Rapidly replacing NIKE-AJAX; well over 80 batteries deployed in U.S.; more than 10 N-H batteries being deployed overseas in 1961; N-H on Formosa
★**NIKE-ZEUS** (Army)	Western Electric, prime; Bell Telephone, guidance; Thiokol/Grand Central, propulsion; Douglas, airframe	Anti-missile; 3-stage; 200-mile range; solid; nuclear	R&D test launchings at White Sands, 19 R&D launchings; 11 successful, 6 partial, 2 failures. Full missile tests to begin this month from Pt. Mugu, Calif.; complete system tests now scheduled for early '62
★**PERSHING** (Army)	Martin, prime; Bendix, guidance, Thiokol, propulsion	Surface-to-surface; two-stage solid; approx. 500-mile range; nuclear; transported on FMC XM474 tracked vehicle; proposed PERSHING II would have 1000-mile range	R&D; to replace REDSTONE; 21 R&D launchings: 17 successes (both stages launched, guidance carried as passenger Dec. 12 for first time), 4 failures. Operational late 1961; R&D launching about 250 miles April 21

PROJECT	CONTRACTORS	DESCRIPTION	STATUS
★**POLARIS** (Navy)	Lockheed, prime; GE/MIT, guidance and fire control; Aerojet-General, propulsion; Lockheed, re-entry vehicle	Underwater and surface-to-surface; solid; 1200-mile range can hit more than 90% all targets in Russia; nuclear; POLARIS II (1500-mile range) and SUPER POLARIS (2500 mile range) under R&D; possible A-4 4000-5000 mile range missile under study	99 launchings of test vehicles; 69 successes; 24 partial; 6 failures; 31 also launched from submerged subs—all cleared surface; 21 successful flights, 10 failures. Four subs each with 16 missiles operational, 5th deploying imminently. Total authorized by White House: 29. POLARISES for cruiser Long Beach cancelled; Polaris II R&D missiles impacting 1400+ n.mi. in guided flight
QUAIL (Air Force)	McDonnell, prime; Summers Gyro, guidance; GE, propulsion; Ramo-Wooldridge, ECM equipment	ECM-carrying bomber decoy; about 200 m. range; jet powered	Deployed at SAC bases; carried by B-52
RAVEN (Navy)	No contract announced	Air-to-surface; about 500-mile range	Study
REDEYE (Army)	Convair, prime; Philco/Convair Atlantic Research, propulsion	Surface-to-air; 4-foot, 20-lb. bazooka-type; IR guidance; solid; conventional; container-launcher disposable	Late R&D; deployment delayed until late 1962; Marines also will use; NATO may buy
REDSTONE (Army)	Chrysler, prime; Ford Instrument, guidance; Rocketdyne, propulsion	Surface-to-surface; liquid; 200-mile range; nuclear	Deployed with U.S. troops in Europe; to be replaced by PERSHING
REGULUS I (Navy)	Chance Vought, prime and guidance; Aerojet-General, propulsion	Surface-to-surface; turbojet & solid; 500-mile range; nuclear	Deployed aboard U.S. submarines; REGULUS II used as target drone
SEMPER (Marines)	No contracts announced	Believed to be an air-launched missile	R&D testing at Pt. Mugu
SERGEANT (Army)	Sperry, prime; Sperry, guidance; Thiokol, propulsion	Surface-to-surface; solid; more than 75-mile range; nuclear	In production
★**SHILLELAGH** (Army)	Aeronutronic, prime	Surface-to-surface; lightweight; can be vehicle-mounted	R&D
SIDEWINDER (Navy-Air Force)	GE-Philco, prime; Philco/GE guidance; Naval Powder Plant, propulsion	Air-to-air; IR guidance; more than 2 m. range; conventional; new I-C models to have switchable IR and radar-guided warheads	Deployed with Navy and Air Force; all-weather type under development
SKYBOLT (Air Force)	Douglas, prime; Nortronics, guidance; Aerojet, propulsion; GE, re-entry vehicle	ALBM; more than 1000-mile range; solid; nuclear; to be launched from B-52, B-70 and Vulcan bombers	R&D; to be purchased by British; operational 1964; test-launching to be from Eglin AFB, Fla. Add. funding restores old operational date
SLAM (Air Force)	No contract announced	Surface-to-surface; low-altitude; supersonic; nuclear ramjet and warhead	Study-R&D
SPARROW III (Navy)	Raytheon, prime; Raytheon, guidance; Aerojet-General, Thiokol propulsion	Air-to-air; 5-8 mile range; Mach 2.5-3; solid and pre-packaged liquid; conventional	Operational with carrier aircraft earlier SPARROW I obsolete; new contract extending range, altitude
SUBROC (Navy)	Goodyear, prime; Kearfott, guidance; Thiokol, propulsion	Underwater or surface-to-underwater; 25-30 mile range; solid; nuclear	Estimated operational date: 1961. To be installed first on Thresher nuclear-powered attack submarine
★**SS-10** (Army)	Nord Aviation, prime; GE, U.S. licensee	Surface-to-surface; primarily antitank; 1600-yards range; 33 lbs. solid; wire guided; conventional	Operational with U.S., French and other NATO and Western units; battle-tested in North Africa; U.S. Army phasing it out
★**SS-11** (Army)	Nord Aviation, prime; G.E., U.S. licensee	Surface-to-surface; also helicopter-to-surface; 3800-yard range; 63 lbs; wire guided; conventional	Operational, to be used with airborne units
TALOS (Navy)	Bendix, prime; Bendix/Sperry, guidance; Naval Propellant Plant, propulsion	Surface-to-surface; 65-mile range; solid & ramjet; Mach 2.5; nuclear	Operational aboard cruiser Galveston
TARTAR (Navy)	Convair, prime; Raytheon, guidance; Aerojet-General, propulsion	Surface-to-air; 10-mile range; Mach 2; 15 feet long & 1 foot in diameter; solid dual-thrust motor; conventional	Operational on Missile Destroyer Adams in Oct.
TERNE (Navy)	Kongsberg Vapenfabrikk, prime; Arma, systems integration	Surface-to-underwater ASW missile; 264 lbs; HE warhead	Navy buying from Norway to equip two destroyer escorts
TERRIER (Navy)	Convair, prime; Reeves/FTL, Sperry guidance; ABL, propulsion	Surface-to-air; 10-mile range; Mach 2.5; 27 feet long; solid conventional	Operational with fleet
TERRIER-ADVANCED (Navy)	Convair, prime; Reeves/FTL, Sperry guidance; ABL, propulsion	About 100% performance improvement over TERRIER	Operational with fleet; being deployed on destroyers and carriers
★**THOR** (Air Force)	Douglas, prime; AC Spark Plug, guidance; Rocketdyne, propulsion; GE re-entry vehicle	Surface-to-surface IRBM; 1500-mile range; liquid; nuclear	Operational; 4 bases (60 launchers) set up in England. 67 military launchings: 46 successes; 11 partial; 10 failures. 56 scientific launchings: 47 successful, 2 partial; 7 failures

PROJECT	CONTRACTORS	DESCRIPTION	STATUS
★**TITAN** (Air Force)	Martin, prime; Bell/Sperry, TITAN I guidance; AC Spark Plug, TITAN II guidance; Aerojet-General, propulsion; Avco, TITAN I re-entry vehicle; GE, TITAN II re-entry vehicle	Surface-to-surface ICBM; 5500-mile range; liquid; 90 feet long; nuclear; TITAN I burns LOX-Kerosene; TITAN II has storable propellants, inertial guidance, bigger payload, greater range, 115 ft. long TITAN III proposed	38 launchings test vehicles: 26 successes; 8 partial; 4 failures. 8 bases for 12 squadrons planned; TITAN I scheduled to be operational mid-1961; TITAN II scheduled operational early 1963; TITAN I successfully launched from TITAN II silo; first TITAN II test scheduled in November
TYPHON (Navy)	Westinghouse, prime; Bendix propulsion	Medium and long range seagoing anti-missile missiles; formerly called SUPER TARTAR and SUPER TALOS; solid booster and ramjet sustainer; conventional; supersonic	Early R&D; may be used on hydrofoil destroyers
WAGTAIL (Air Force)	Minneapolis-Honeywell, prime	Family of airborne RLM's (rear-launched missiles): air-to-air and air-to-surface	Late R&D
WILLOW (Army)	Chrysler, prime	Highly-classified missile	R&D
ZUNI (Navy)	Naval Ordnance Test Station, prime; Hunter-Douglas, propulsion	Air-to-air, air-to-surface; solid; unguided; 5-m. range; conventional	Operational

Space Vehicles

AGENA (Air Force)	Lockheed, prime; Bell, propulsion	1700-pound satellite after burnout; AGENA B stop-start 2450-lb. engine; about double fuel capacity of AGENA A	Used in DISCOVERER program; larger AGENA B also to be used with ATLAS and THOR
BLUE SCOUT (Air Force)	Aeronutronic, prime; Minneapolis-Honeywell, guidance; Aerojet/Hercules, Thiokol, propulsion	Solid multi-stage booster based on SCOUT components	Operational
CENTAUR (NASA)	Convair, prime; Pratt & Whitney, propulsion; Minneapolis-Honeywell, guidance	Pair of LOX-liquid hydrogen engines; 30,000 lbs. total thrust, atop ATLAS booster, capable orbiting 8500 lbs. launching 1450-lb. space probe.	First test flight in 1961; first engine delivered
DELTA (NASA)	Douglas, booster; Bell, guidance; Rocketdyne/Aerojet/ABL, propulsion	Successor to THOR-ABLE; upper stage guidance; 480 lb. payload capacity	Interim launch vehicle for TIROS-ECHO; being used for other satellites and one deep space probe
★**NOVA-L** (NASA)	No prime announced; Rocketdyne, propulsion	Clustered 6-12 million lb. liquid propellant booster plus upper stages	R&D on 1.5 million lb. F-1 engines; vehicle contract expected to be awarded this fall; F-1 test-fired 19 times at more than 1 million lbs. thrust
NOVA-S (Air Force)	No contractor announced; expected to be based on Aerojet/Grand Central feasibility studies	Clustered 12-million—20-million-lb. booster; possible alternative to NOVA-L	R&D; contracts expected to be let shortly
ORION (Air Force)	General Atomic	Space booster launched by series of atomic explosions	Advanced engineering studies under way; tests may be attempted
PHOENIX (Air Force)	No contracts announced	Recoverable booster—possibly a modified F-1	Studies
★**ROVER** (NASA, AEC)	Aerojet, prime	First nuclear rocket: KIWI non-flying test engines and NERVA flight engines	First hot run of KIWI-B test unit at Nevada test site in October
★**SATURN** (NASA)	Marshall Center, prime and booster; Douglas and Convair, upper stages; Rocketdyne, booster and mid-stage engines; Pratt & Whitney, top-stage engines	Series of multistage vehicles based on 1.5-million-lb. clustered booster and various upper stages of LOX-liquid hydrogen engines. Early model to orbit 20,000-lb. payload	First SATURN booster being readied for first launching in Oct. at Cape; flight with live upper stages scheduled 1963. C-2 killed, C-3 to have 2 F-1's in 1st stage.
SCOUT (NASA)	Chance Vought, prime; Minneapolis-Honeywell, guidance; Aerojet-General/Hercules/Thiokol/ABL, propulsion	Solid four-stage satellite launcher; 200 lb. payload in orbit	SCOUT flights in '61 completes R&D; Navy proposing SEASCOUT for seaborne surface launch, would be based on POLARIS and SCOUT
THOR-ABLESTAR (Air Force-NASA)	STL, prime; Rocketdyne/Aerojet-General/ABL, propulsion	Three-stage vehicle, orbital capability 800 lbs. Upper stage has restart engine	THOR-ABLE phased out. THOR-ABLESTAR operational in TRANSIT and COURIER

Satellites in Orbit

★**EXPLORER I** (30.8 lbs.) U.S. Launched 1/31/58, est. life 7-10 years. Orbits earth; perigee 217 m., apogee 1108 m., period 106.4 min. (Discovered Van Allen Belt); not transmitting.

★**VANGUARD I** (3.25 lbs.) U.S. Launched 3/17/58, est. life 200-1000 years. Orbits earth; perigee 404, apogee 2448, period 133.8; transmitting.

LUNIK I "MECHTA" (3245 lbs.) Russia. Launched 1/2/59. Believed to be in orbit around sun on 15-mo. cycle; not transmitting.

★**VANGUARD II** (20.7 lbs.) U.S. Launched 2/17/59, est. life 100-250 years. Orbits earth but is "wobbling"; perigee 344, apogee 2046, period 125.3; inclination to equator 32.88°; not transmitting.

PIONEER IV (13.4 lbs.) U.S. Launched 3/3/59. Orbits sun, and achieved primary mission—earth-moon trajectory; not transmitting.

EXPLORER VI "PADDLEWHEEL" (142 lbs.) U.S. Launched 8/7/59. Orbits earth; initial perigee 156, initial apogee 26,357, initial period 12½ hrs., present orbit uncertain.

★**VANGUARD III** (about 100 lbs.) U.S. Launched 9/18/59, est. life 50-150 years. Orbits earth; perigee 317, apogee 2320, period 129.8; not transmitting.

EXPLORER VII (91.5 lbs.) U.S. Launched 10/13/59, est. life 30-40 years. Orbits earth; perigee 344, apogee 669, period 101.1; transmitting.

★**PIONEER V** (94.8 lbs.) U.S. Launched 3/11/60, est. life forever. Orbits sun, interplanetary environment probe; completed one full orbit 1/16/61; aphelion .9951 au, perihelion .8061 au, not transmitting.

★**TIROS I** (270 lbs.) U.S. Launched 4/1/60, est. life 50-150 years. Orbits earth; picture-taking weather satellite; perigee 429, apogee 467, period 99.1; transmitting.

★**TRANSIT IB** (265 lbs.) U.S. Launched 4/13/60, est. life 6 years. Orbits earth; perigee 229, apogee 412, period 94.9 First R&D navigation satellite. Not transmitting.

★**SPUTNIK IV** (10,008 lbs.) Russia. Launched 5/15/60, est. life 2-3 years. Orbits earth; initial perigee 188, apogee 229—changed to 191/429 on 5/19/60; last reported—perigee 175, apogee 309, period 92.3 Test of support systems, cabin, for manned space flight; attempt to return from orbit failed; payload, case and two pieces now in orbit. Not transmitting.

★**MIDAS II** (5000 lbs.) U.S. Launched 5/24/60, est. life 8-15 years. Orbits earth; perigee 297, apogee 314, period 94.3 Telemetry for IR scanning failed two days after launch. Not transmitting.

TRANSIT II-A (223 lbs.) U.S. Launched 6/22/60, est. life 50-200 years. Orbits earth, perigee 389, apogee 649, period 101.6. Transmitting.

NRL SOLAR RADIATION SATELLITE I (40 lbs.) U.S. Launched 6/22/60 with TRANSIT II-A, est. life 50-200 years. Orbits earth; perigee 381, apogee 657, period 101.6. Not transmitting.

★**ECHO I** (132 lbs.) U.S. Launched 8/12/60, est. life 2-16 years. Orbits earth; perigee 823, apogee 1098, period 116.9. First successful orbiting of passive communications satellite.

COURIER IB (500 lbs.) U.S. Launched 10/4/60, est. life 200-500 years. Orbits earth; perigee 604, apogee 750, period 106.9. First successful launching of delayed active repeater satellite. Transmitting.

★**EXPLORER VIII** (90 lbs.) U.S. Launched 11/3/60 by JUNO II, est. life 20-50 years. Orbits earth, perigee 262, apogee 1410, period 112.5. Provides ionospheric measurements for communications. Not transmitting.

TIROS II (280 lbs.) U.S. Launched 11/23/60, est. life 200-500 years. Orbits earth; perigee 378, apogee 461, period 98.2. Transmitting.

SAMOS II (4100 lbs.) U.S. Launched 1/31/61. Orbits earth; perigee 295, apogee 342, period 94.9. First R&D reconnaissance satellite.

★**VENUS PROBE** (1419 lbs.) Russia. Launched 2/12/61, aphelion 1.0190 au, perihelion 0.7183 au.

★**EXPLORER IX** (15 lbs.) U.S. Launched 2/16/61. Orbits earth; perigee 431, apogee 1562, period 118.1. A 12-ft. "polka dot" balloon.

★**DISCOVERER XX** (2450 lbs.) U.S. Launched 2/17/61. Orbits earth; perigee 176, apogee 420, period 94.3. No attempt to recover 300-lb. capsule because of malfunction.

★**DISCOVERER XXI** (2100 lbs.) U.S. Launched 2/18/61. Orbits earth; perigee 154, apogee 524, period 95.6. Carried IR equipment for MIDAS program to measure background radiation from earth.

EXPLORER X (78 lbs.) U.S. Launched 3/25/61. Last known position: perigee 110, apogee 112,500, period 5012. Optical-pumping magnetometer. Position uncertain.

★**DISCOVERER XXIII** (2100 lbs.) U.S. Launched 4/8/61. Orbits earth; perigee 183, apogee 349, period 93.2. Capsule ejected in wrong direction, sending it further into space. Not transmitting.

★**EXPLORER XI** (82 lbs.) U.S. Launched 4/27/61. Orbits earth; perigee 302, apogee 1110, period 107.9. Measures gamma rays from the stars absorbed in earth's atmosphere.

★**TRANSIT IVA** (IVA, 175 lbs., GREB III, 55 lbs.; INJUN, 40 lbs.) U.S. Launched 6/29/61. Orbits earth; TRANSIT—perigee 547, apogee 620, period 103.8. GREB-INJUN—perigee 548, apogee 619, period 103.8. Transmitting. GREB III and INJUN failed to separate after three-in-one launch.

★**DISCOVERER XXVI** (2100 lbs.) U.S. Launched 7/7/61. Orbits earth; perigee 142, apogee 436, period 94.0. Systems evaluation of AGENA B. Capsule recovered.

★**TIROS III** (285 lbs.) U.S. Launched 7/12/61. Orbits earth; perigee 457, apogee 511, period 100.3. Transmitting cloud cover weather pictures.

★**MIDAS III** (3500 lbs.) U.S. Launched 7/12/61. Orbits earth, perigee 2084, apogee 2197, period 161.5. IR early warning satellite.

★**EXPLORER XII** (83 lbs.) U.S. Launched 8/15/61. Orbits earth; perigee 180, apogee 47,800, period 26½ hours. Study Van Allen belts and energetic particles in space.

★**RANGER I** (675 lbs.) U.S. Launched 8/23/61. Orbits earth after failing to achieve planned long eccentric orbit; perigee 105, apogee 312, period 91. Experiments operating but not sending desired information on magnetic fields because of near earth orbit.

(Orbital data is latest official information as of 1200 Z, August 15, 1961)

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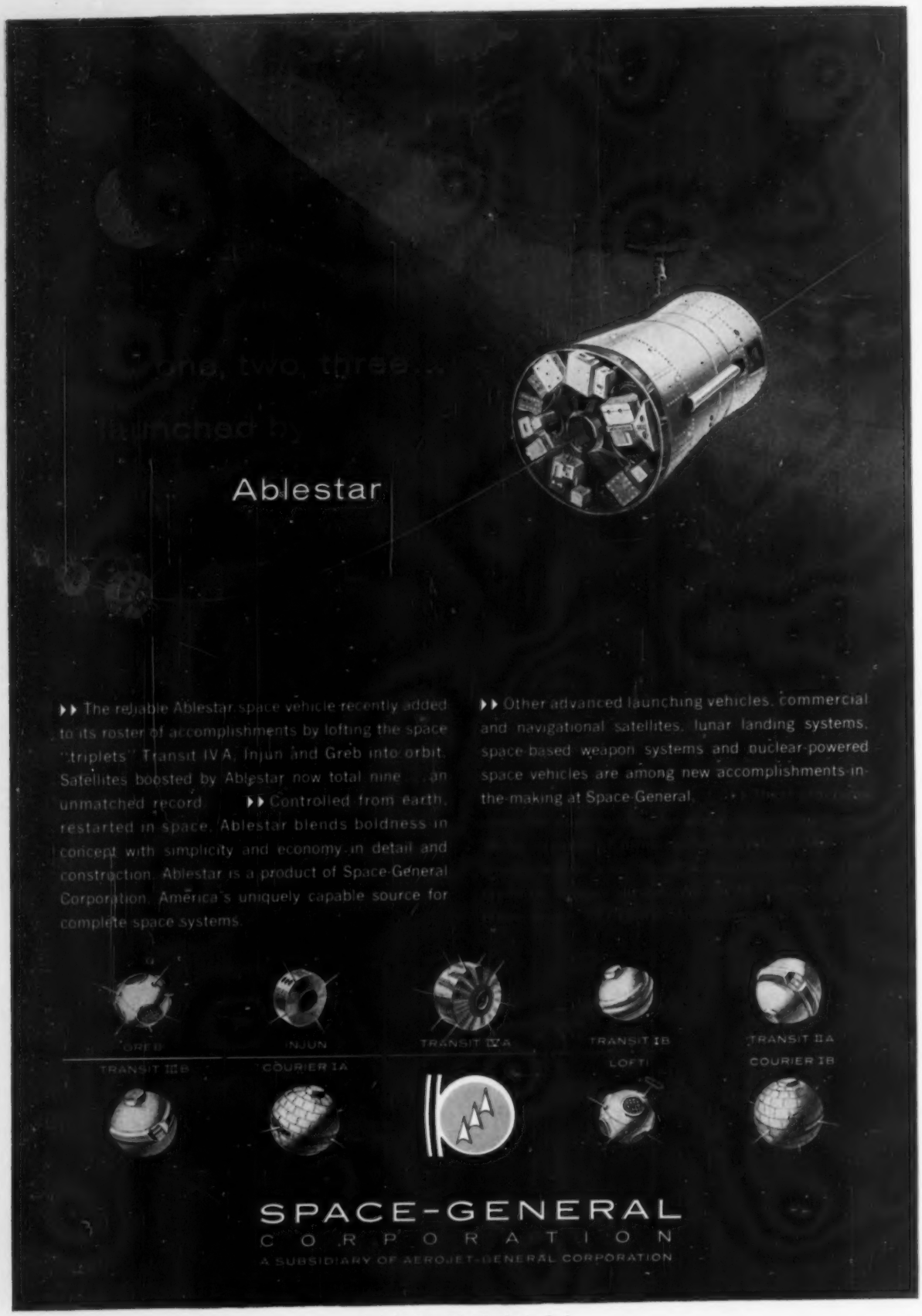

▸▸ The reliable Ablestar space vehicle recently added to its roster of accomplishments by lofting the space "triplets" Transit IV A, Injun and Greb into orbit. Satellites boosted by Ablestar now total nine . . . an unmatched record. ▸▸ Controlled from earth, restarted in space, Ablestar blends boldness in concept with simplicity and economy in detail and construction. Ablestar is a product of Space-General Corporation, America's uniquely capable source for complete space systems.

▸▸ Other advanced launching vehicles, commercial and navigational satellites, lunar landing systems, space-based weapon systems and nuclear-powered space vehicles are among new accomplishments in the making at Space-General.

GREB
TRANSIT IIIB
INJUN
COURIER 1A
TRANSIT IVA
TRANSIT 1B
LOFTI
TRANSIT IIA
COURIER 1B

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Ratemeters Being Developed for Jells

Use of thixotropic fuels is being brought nearer through techniques explored by AF's Applied Radiation Lab

A MAJOR KEY to future use of thixotropic propellants is the development of a mass flow ratemeter for the jelled mixes. No such instrument is now available.

One promising approach for jelled propellant mass flow rates is the application of gamma ray absorption techniques, according to Capt. R. J. Darby and Lt. J. F. Wakeman, project engineers at the Applied Radiation Laboratory, Liquid Systems Div., Directorate of Rocket Propulsion, Edwards AFB, Calif. Use of this method (Fig. 1) has provided both high- and low-level tank propellant level indications.

The system uses collimated Cesium-137 sources together with a Geiger-Mueller detector operating through a ratemeter and a switching circuit. (Fig. 1). The high-level detector automatically closes the solenoid-operated propellant fill valve, and the low-level detector automatically cuts off engine firing at a predetermined tank level.

• **Highly accurate**—Because of the slow rate of tank filling, the high-level detector makes it possible to control propellant level in the run tanks to ±.125 in.—or an overall accuracy of ±0.2% in relation to the total fuel mass of the tank being employed.

The low-level detector circuit, which controls the main propellant run valves, shuts off the engine at a propellant level of approximately one inch below the detector source location.

The one-inch overrun represents a system lag of approximately one-half second. The lag is due primarily to the time constant of the ratemeter plus the time delays of the solenoid-operated valves. The one-inch lag, however, is both predictable and reproducible, resulting in a tank level accuracy of ±0.250 in. at the predetermined point of engine cutoff. The latter figure represents ±0.4% of the tank's total propellant.

Although the system was built primarily for accurate tank filling and for an approximate engine cut-off point in relation to propellant remaining, it also provides an approximate overall mass flow rate for the engine during the firing time. Another function of the system is to furnish test personnel with a means of calculating overall engine parameters.

Improvements in the ratemeter switching system and relays, and the ratemeter time constant, are expected to provide even higher accuracies in the system.

• **Another approach**—Atomics International Division of North American Aviation is currently conducting a study program for the Applied Radiation Lab to develop ARL's existing propellant utilization system for further flow studies of thixotropic propellants.

The approach will consist of a study of multiple Cesium-137 source locations so as to provide a linear output signal proportional to the propellant mass remaining in the tanks at any given time. (Fig. 2).

AI will also study the possibility of using a newly developed, high-signal-to-noise ratio photomultiplier tube to give an analog voltage output. Successful use of the tube, produced by the Schlumberger Co., would enable AI to construct an instantaneous mass flow meter with accuracies on the order of ±2%.

• **Jells promising**—Thixotropic propellant development has been under way for some time at the Directorate of Rocket Propulsion, under the overall propellant study of Project *Joshua*. Advantages claimed for the jelled propellant approach include a reduction in handling problems, a decreased rate of vaporization and a minimum amount of leakage during transfer operations.

The Edwards unit has fired some jelled-propellant small rocket motors with good results, but there are still many operational problems to be solved —pumping of the propellant jell, tank filling as well as propellant mass flow measurement.

The Directorate of Rocket Propulsion has been studying and working with monopropellant jells and has recently constructed facilities for test of thixotropic propellants in motors of up to 5000 lbs. thrust. ⌗

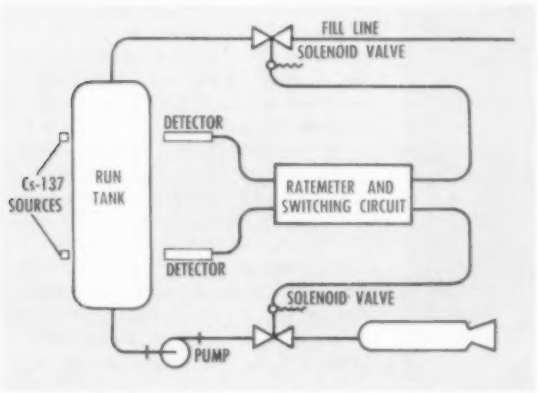


FIG. 1—*Collimated Cesium-137 sources with Geiger-Mueller detector operating through ratemeter and switching circuit.*

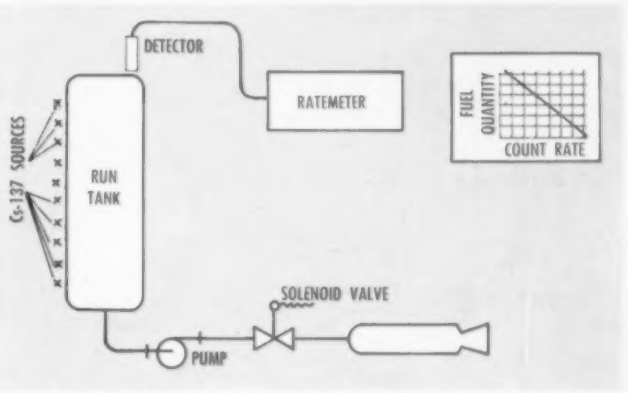


FIG. 2—*Multiple Cesium-137 sources provide linear output signal proportional to mass remaining in tanks.*

A-G Looks for Big Solid Test Site

Areas in Florida, Texas and on West Coast considered as possibilities; million-lb. firing to close test series?

by Frank G. McGuire

AEROJET-GENERAL is actively seeking a new site for the development and testing of large solid-propellant boosters. The facility is expected to sprawl over between 25,000 and 80,000 acres.

The actual spot will be chosen within 90 days. It will have to be near the ocean and a large metropolitan center, have adequate water and transport, and meet several other requirements.

Teams from the firm have studied possible areas in Dade County, Fla., Corpus Christi, Tex. and three West Coast sites. Aerojet's Executive Vice President W. E. Zisch says the site will be used for large boosters only; this effectively squelches any speculation that the firm intends to switch a significant share of its work out of Sacramento.

Best bet to head up the new facility is Dr. E. R. Roberts, director of the large solid work at Sacramento. Although no official statement has been made, Roberts conceded he "might have some sort of significant part" in the projected setup.

First indications of such a move came at the announcement of the formation of Space-General Corp., a subsidiary of Aerojet-General. (M/R, July 3, p. 16).

• **"Go for broke?"**—Elsewhere on the booster front, Aerojet is preparing for the fifth and final test in the large-solid feasibility program currently being conducted for the Air Force Space Systems Division.

Final objectives for this test have not yet been spelled out but there is speculation that the Air Force may "go for broke"—as with the first full-scale *Minuteman* firing— and try for the full million-lb. thrust, 90-second firing.

The four-segment FW-2 motor generated just under 500,000 lbs. thrust in its most recent firing, on Aug. 26. It burned for 87 seconds. This entire motor is expected to be involved in the final test, but with one more segment added. A freon-injection thrust-vector control system will also be included.

During the last test, the burning rate in the four-segment motor was determined through radioisotopes. Company technicians carefully placed pellets containing radioactive material at nine different locations in the propellant mass.

The pellets, provided by Aerojet-Nucleonics, were coated with propellant and then given a special covering.

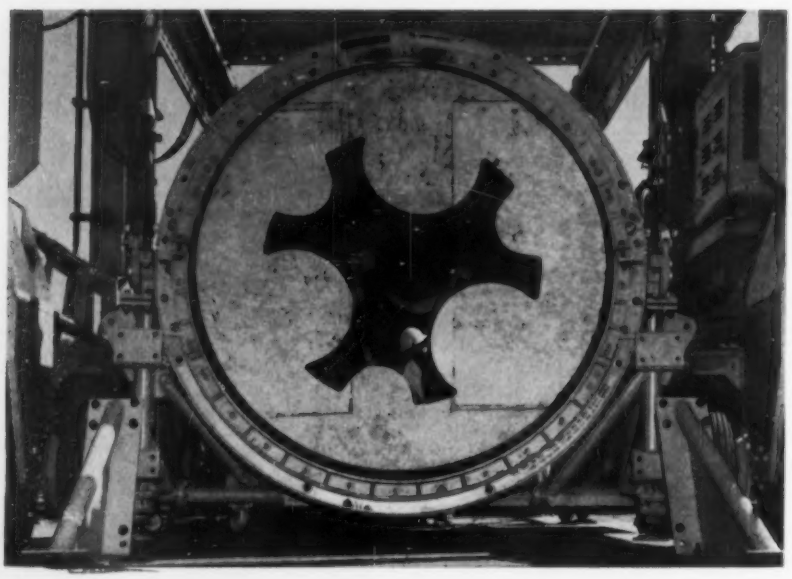
Detectors located around the motor were able to sample radiation from the pellets—and transmit the changed radiation count as the pellets were destroyed by the advancing burning surface.

Company spokesmen said the burning rate has been precisely determined with this technique, and the low-energy pellets provide just enough radiation to do their job without endangering personnel.

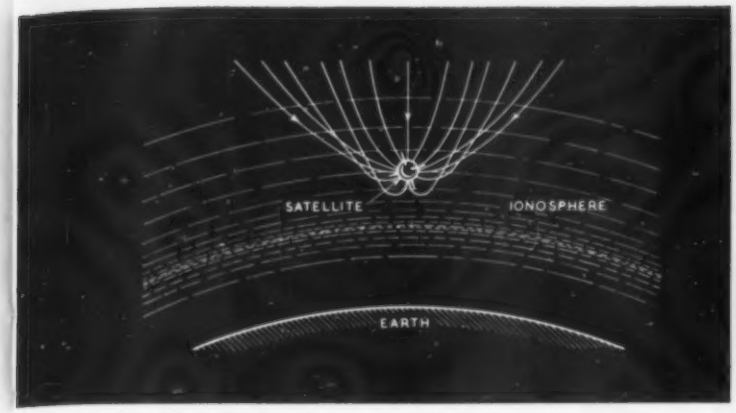
About 80 tons of propellant was involved in the FW-2 firing. Motor length was 42 ft., diameter 100 in. The segments were given a restrictive coating on the ends of the propellants to prevent end burning and an intolerable pressure increase.

A stationary plastic nozzle with a carbon throat insert was used and no thrust vector control was tested. Nozzle char was relatively light and no undue damage was observed.

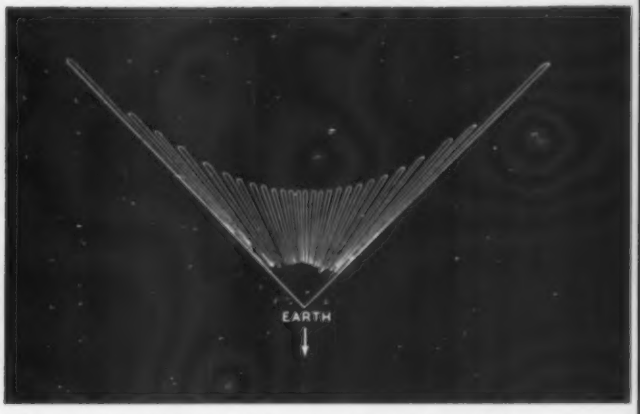
Acoustical level was estimated by Aerojet officials to be approximately that of the *Titan II* first-stage engine. They said no problems have been encountered with acoustical levels in engine tests. Case wall thickness was not revealed, but company officials said it was not unusually thin. ⁂



BELOW: *Cross-section configuration of the 100-in. Aerojet segment is revealed as components are mated on the test stand. The second center chamber segment is visible behind the technician.*



RAY FOCUSING of light from space by the ionosphere.



RECEPTION PATTERN of elementary dipole above F layer.

electronics

Using Earth in Huge Antenna System

THE FOLLOWING ARTICLE was extracted from the July issue of British Communications and Electronics. Originally titled "Radio Astronomy from Space Vehicles," it was written by R. C. Jennison, B.Sc., Ph.D., F.R.A.S., of the University of Manchester and Nuffield Astronomy Laboratories, Jodrell Bank, Cheshire, England.

EMPLOYING the earth and its ionosphere as part of a vast antenna system may make it possible to broaden the horizons of the radio astronomer to include observations of the electromagnetic spectrum below 15 mc.

Previously, except for the rather uncertain measures of sky brightness by Reber and Ellis at frequencies between 0.5 and 5.0 mc, observations have been limited by the interference of the earth's ionosphere and terrestrial noise.

The resolving power of a telescope to study these low frequencies would have to be approximately 1500 times that of the largest radio telescope at Jodrell Bank. Thus, an earth-based system appears to be completely unfeasible. The same considerations of antenna size make it impractical to carry the telescope system into space.

However, by locating some object many wavelengths across which may be persuaded to function as part of the antenna system—the earth and its ionosphere—it is possible to solve the problem.

There are two equivalent ways of regarding the combination of an elementary antenna and the earth's ionosphere. Both involve earth-orbiting satellites. However, in one system, the satellite would be above the ionosphere while, in the second, the satellite would be within the ionized medium.

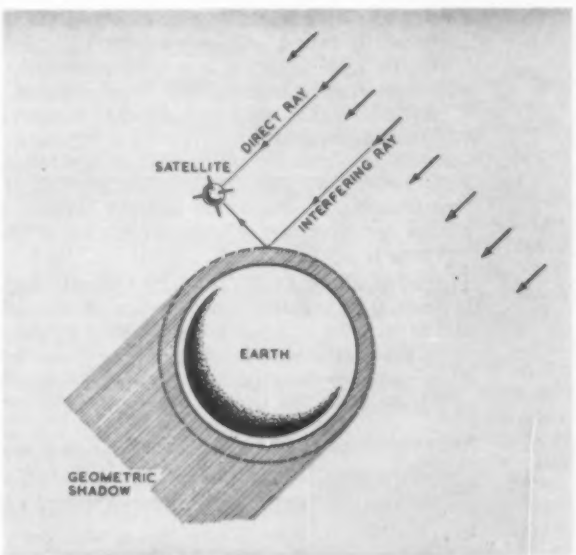
• **System functioning**—In the latter system, the refractive medium, whose refractive index decreases and becomes zero at the critical height above the F layer, bends the ray paths to the small satellite area so that the reception angle is confined to a cone around the satellite. The angle of this cone depends upon the frequency of observation and the electron density at the height of the vehicle.

This focusing of the ray paths in the ionosphere can in principle be used as a high-gain antenna, similar to a refracting telescope to map the sky at low frequencies.

Although interference effects would be encountered as a result of a combination of the direct ray and the ionosphere-reflected ray in the higher-orbiting satellite, this system would be no less valuable in low-frequency mapping of the sky. This can be appreciated when the edge of the reception cone is considered as the limit of the earth's shadow, while the interference caused by the reflection path from the top of the ionosphere results in breaking up the reception pattern within the cone into a number of fine concentric lobes.

These interference lobes may be used as an alternative technique to produce the equivalent of an antenna of gigantic proportions. Sweeping over the sky as the satellite orbits the earth, these lobes may be expected to produce a high-level signal, almost constant in amplitude, from the broad structure of the galactic corona.

• **Output differentiation**—The flux



EFFECTS OF EARTH'S shadow and interference characteristics are shown in drawing of satellite-earth antenna system.

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from individual small bright regions or point sources in the sky would be considerably less than that from the whole sky. Therefore, the telemetry output from the satellite's receiver must be differentiated and the small point sources amplified to a suitable level for transmission to ground stations.

Treated in this manner, the simple dipole aerial system in the satellite is transformed into the primary feed of a vast interferometer type antenna a thousand miles across.

It is likely that at these wavelengths the majority of the signals received will come from the corona of the galaxy where relativistic electrons may emit intense radio waves by a synchrotron process. Thus from the neighborhood of the earth the whole sky may appear bright, with a dark band running along the Milky Way itself, where the clouds of ionized gas of greater density (a few atoms per cubic centimeter) are sufficient to obscure the radiation from greater depths. The well-known radio stars Cassiopeia, Cygnus and Taurus lie close to the plane of the Milky Way; even if they could still radiate at very long wavelengths, they would also be subject to this obscuration.

The quiet sun is not a powerful emitter at long wavelengths, and it would not be prominent. Active bursts from the disturbed sun might, however, produce extremely strong signals. (It is worth noting that the apparent size of the sun at very long wavelengths may be very much greater than in the optical spectrum.)

The planet Jupiter is known to emit very strong bursts, similar to atmospherics, but much more intense, at frequencies close to 20 mc. It is not known if Jupiter or other planets show similar emissions at lower frequencies; this is one of the exciting unknowns in this part of the spectrum.

The discovery of the Jupiter emissions was itself quite unexpected and is a good indication of how unwise it is to try to predict every feature which may be observed over a range of octaves as vast as that available to satelliteborne receivers.

There may be many fascinating new sources of radio waves quite undreamed of in our existing knowledge of the universe. And the earth satellite may be the only practical means of discovering and plotting these sources.

For example, Venus is permanently covered in a layer of ten tenths cloud, preventing optical observations of its surface or lower atmosphere. A satellite-borne spectrometer utilizing the systems outlined above would make it possible to search for water vapor and oxygen bands at 1½ cm and 5 mm respectively by absorption against radiation from the planet's surface. ⁂

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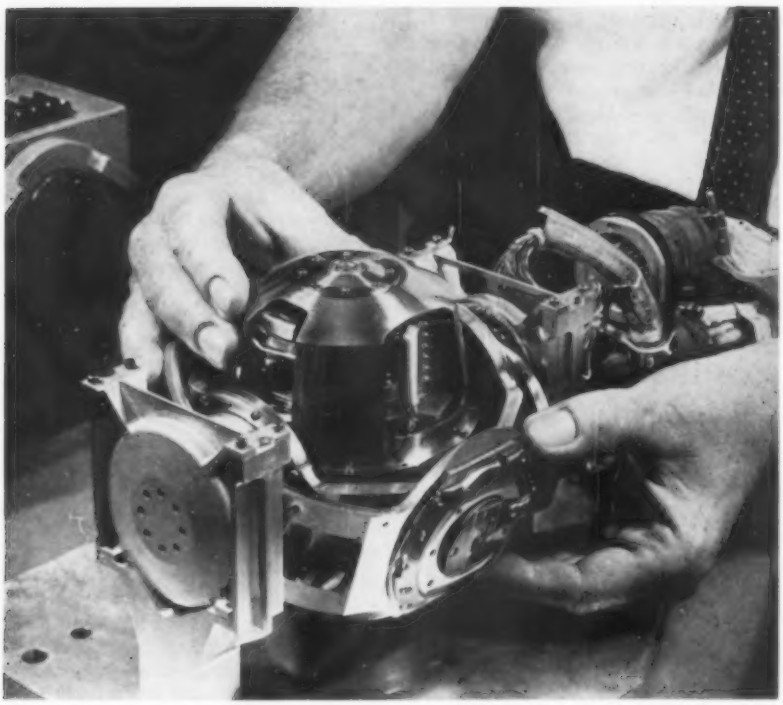
Spaceship Platform Nears Flight Test

Litton expects to break into missile guidance field with new inertial package scaled down from popular P-200 unit used in aircraft; gas spin bearings employed in gyros

by Charles D. LaFond



NEW P-300 inertial reference platform (shown without cover) weighs 15 lbs. and occupies only 0.2 cu. ft. of space. Platform is a subsystem of an experimental flight data system being developed for the Air Force by Litton Systems, Inc.

BEVERLY HILLS, CALIF.—A new "off-the-shelf" miniature stable platform, developed for Air Force orbital and suborbital space vehicles, will be flight-tested within the next few weeks.

Designated P-300, the 15-lb. 0.2-cu.-ft. inertial package is the first of three subsystems to be completed by Litton Systems, Inc., that will be used to establish feasibility of an integrated Flight Data System. The program, under way for two years, is directed by the Flight Control Laboratory of the Aeronautical Systems Division, Wright Field.

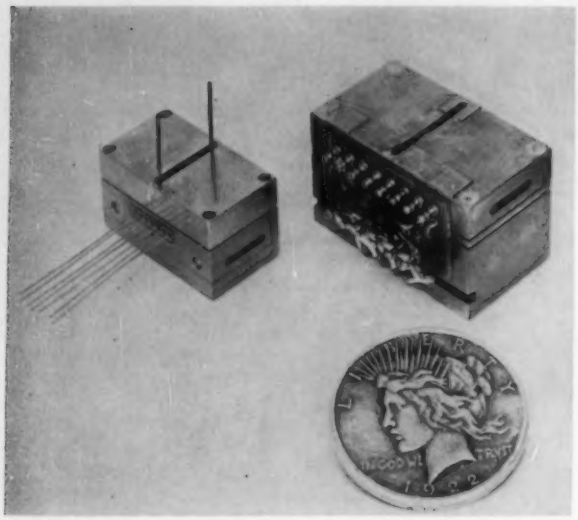
A miniaturized digital computer and air-data sensors will complete the integrated system.

As a result of the contract, the Air Force hopes to prove that such a system can provide all required control data for orbital and suborbital spacecraft. These data are to be supplied during all phases of operation from launch into glide and through re-entry and subsequent recovery.

Litton recently qualified a production platform using similar design features for missile environments on the rocket test sled at Naval Ordnance Test Station, China Lake, Calif. Not now a missile guidance supplier, Litton feels it can successfully break into the field with its new system.

• **Predecessor widely used** — The new platform is a scaled-down version of the widely used P-200 inertial reference unit. More than twice the weight of the minified platform, the Litton P-200 has been ordered by Canada, Belgium, the Netherlands, West Germany and Italy for the F-104 supersonic jet fighter and by the U.S. Navy for the WF-2, W2F, A2F and P3V aircraft. Two somewhat earlier models are to be used in the XB-70 flight tests for altitude reference.

• **P-300 details** — Function of the new platform is to provide measurements of vehicle attitude and acceleration with respect to any desired coordinate system. The stable element employs two beryllium two-degree-of-freedom gyros and three torque-balance accelerometers. The inertial elements are supported by four gimbals which permit unlimited angular freedom of the vehicle about three axes.



TYPICAL SIZE reduction obtained by Litton in development of its space vehicle guidance package is shown with comparison of accelerometers. The A-300 accelerometer (left) has been made significantly smaller than its predecessor (right), used in the Lockheed F-104 inertial navigation system.

The three accelerometers are mutually orthogonal and are oriented so that accelerations are sensed along all three axes. Velocity information from the accelerometers is supplied to a digital computer for computation of position and generation of corrective gyro torques. Inertial platform alignment may be accomplished by automatic gyrocompassing or other more newly developed techniques.

The P-300 gyros and accelerometers were both reduced in size and weight from the corresponding P-200 units as a result of Litton's development program. Two-degree-of-freedom gyros again were selected, developers said, enabling a simplification of electronics in comparison with one-degree-of-freedom-gyro platforms. The earlier system used aluminum gyros and geared torquers instead of the present direct-drive torquers.

The complete package measures (roughly) 9.5 in. lg. x 6 in. x 6.5 in.

• **New bearing design**—Gyro size is 2.1 in. x 2.9 in. and weight is less than 2 lbs. The float containing the rotor is approximately 2 in. in diameter.

Despite their small dimensions, Litton says, the P-300G gyros can be supplied with a random drift rate of only 0.001 degree per hour. Other specifications include:

—Mass unbalance—0.01 deg/hr/g

—Anisoelasticity—0.003 deg/hr/g^2

—Maximum torquing rate—3000 deg/hr

—Operating life—20,000 hr

—Angular momentum—0.7 x 10^6 gm-cm^2/sec

—Synchronous speed—24,000 rpm

In the most significant design change, gas spin bearings are employed in the new gyros. Perfection of this technique in itself improved performance of the precision gyro by approximately one order of magnitude, Litton engineers report. In addition, they believe, precise day-to-day repeatability is improved.

Conceptually, the self-acting, gas lubricated bearing assembly is similar to the oil-lubricated bearings used in large machinery. However, the gaseous lubricant requires a clearance between the bearing surfaces several orders of magnitude smaller than the clearance used in oil-lubricated bearings. Production techniques developed and in use for Litton's LN-3 system, utilizing the P-200 platform, will enable the company to produce the gyros in quantity even though micro-tolerances must be held.

Gas bearings offer four significant features, based on long-term test results:

1) There are no highly-stressed areas. The area supporting the load is approximately 2000 times greater than that of a ball bearing, and the surface stress is lowered accordingly. Reduced stress means a significant reduction in structural creep, resulting in improved day-to-day repeatability.

2) No metal-to-metal contact occurs between the bearing surfaces once the rotor is started. Therefore, no bearing wear occurs during operation of the gyro, and this brings savings in overhaul time and money.

3) Mechanical noise is reduced. In a ball bearing, small irregularities cause appreciable mechanical vibration. In a gas bearing, irregularities do not cause relative movement of the bearing and journal centers because the bearing load is distributed over a large area. Reduction in vibration means a reduction in drift from torque-rectification.

4) Thermal conductivity through a gas-lubricated bearing is much greater than that through an equivalent ball bearing because of the greater contact surface area. Temperature dispersion is more uniform and thermal gradients are minimized.

Verification of these factors was obtained on drift-tests of the prototype unit. In addition, a gyro rotor was subjected to 85,000 start-stop cycles with no significant signs of wear.

Despite the smaller size of the gyro rotor, high angular momentum is obtained by efficient distribution of rotor mass which provides a large radius of gyration.

Litton points out that many floated gyros, particularly conventional single-degree-of-freedom, rate-integrating types, require appreciable damping. This damping is usually obtained with a flotation fluid of high viscosity, requiring elevated temperature to avoid solidification.

Production problems are introduced because air bubbles must be kept from the fluid while the gyro case is being filled, and thermostatic heating must be provided throughout the life of the gyro. With Litton's gyro design, however, low-viscosity fluid can be used. The flotation fluid selected remains liquid down to approximately −57°C.

The outer case of the gyros was designed to provide more compact stable element packaging, greater ease of assembly, more complete and effective magnetic shielding, and increased case rigidity. The case is hermetically sealed by soldering, and permits minimum expansion coefficient differentials.

• **Small but sensitive**—Although the accelerometers (A-300) for the new inertial reference unit are similar in design to the A-200's used in the P-200 platform, the company asserts that they too have been reduced in size and incorporate significant design improvements. Size is 0.8 x 0.5 x 1.5 in. and weight is 2.6 ounces.

Most sensitive element in all its accelerometers, says Litton, is a floated pendulum mounted on a pair of jewel-and-pivot bearings and equipped with an electro-magnetic pickoff and torquer.

An acceleration of as little as 2 x 10^{-5}g along the sensitive axis causes the floated pendulum to rotate about its pivot axis. This rotation, however, is immediately sensed by the pickoff, which generates a signal to an external amplifier. The amplifier in turn generates a torquing signal to return the pendulum to zero.

Current required to maintain the pickoff signal at null is a precise function of the applied acceleration.

High pickoff sensitivity and restoring amplifier gain keep the relative motion of the pendulum limited to a small fraction of a milliradian even in the presence of acceleration of over 20g, Litton engineers claim.

They add that scaling down of the

older accelerometer was accomplished with no decrease in sensitivity.

In all the company's accelerometers, the pendulous element is floated to achieve neutral buoyancy at the operating temperature of the flotation fluid. This, Litton feels, reduces the loading on the jewel-and-pivot bearings so that friction becomes negligible. In addition, the flotation fluid provides enough damping to make the balancing servo system relatively easy to stabilize.

In order to absorb the thermal expansion of the small volume of fluid, a miniature aneroid bellows is designed into the accelerometer assembly.

• **Non-gimbal lock**—The gyros and accelerometers for each axis are on a stable element isolated by four gimbals from the rest of the inertial reference unit and, therefore, from the changes in attitude of the vehicle. These give unrestricted maneuverability along any axis.

Gyros are rigidly attached back-to-back, one turned 90 degrees from the other. Thus, a more compact structural configuration replaces the "dumbbell" arrangement of earlier Litton stable elements.

A hermetically sealed cover envelops the stable platform. After the cover is sealed to the base it is filled to standard atmospheric pressure with a mixture of nitrogen and helium. A blower forces air over a heat exchanger mounted in the platform cover for cooling.

• **Electronics unit**—An electronics unit also is considered a component of the P-300 inertial subsystem. The unit contains all the circuitry necessary for operation of the inertial unit and for communication with its digital computer.

The platform electronics unit contains the gimbal servo amplifiers, accelerometer restoring amplifiers, redundant azimuth gyro-axis caging amplifier, power supplies, platform temperature-control circuits, digital converter and switching circuits.

For the flight data system, analog outputs from the accelerometer are converted to binary incremental velocity data for the digital computer. In addition, binary incremental gyro torquing signals from the digital computer are converted to precision pulses for gyro pulse-torquing.

Solid-state circuitry in the electronics unit makes extensive use of d-c amplification to reduce the number of bulky components such as transformers. Using established packaging techniques, the electronics unit—including conversion and pulse torquing circuitry—weighs approximately 18 lbs. and occupies about 0.3 cu. ft. A more advanced version, utilizing micro-circuitry, is expected to have half that weight. ⌗

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Orbital Fuel Storage Conditions Are

NASA experts find little-studied non-vented tanks concept is especially superior for liquid hydrogen when sub-cooling is used

DESIGN PARAMETERS affecting the orbital storage of liquid hydrogen have been established by two National Aeronautics and Space Administration scientists.

J. R. Olivier and W. E. Dempster of the George C. Marshall Space Flight Center, Huntsville, Ala., analyzed the factors involved in storing 40,000 lbs. of liquid hydrogen in a 300-mile geocentric orbit.

Most investigations of on-board vehicle hydrogen conservation are not applicable to orbital storage because of basic heat flux differences. The majority of these studies deal only with vented storage; few give even superficial consideration to non-vented applications.

Preliminary studies established the feasibility of long-term orbital LH_2 storage using a subcooled liquid under non-vented conditions. The NASA experts conclude that non-vented storage has technical and economic advantages over the vented tank concept.

The thermal environment of an orbiting tank is defined by radiant thermal energy from direct solar sources, the earth albedo and earth infrared.

Direct solar radiation will irradiate the tank outside the earth's shadow. The proper choice of tank surface properties will alleviate this through reflection.

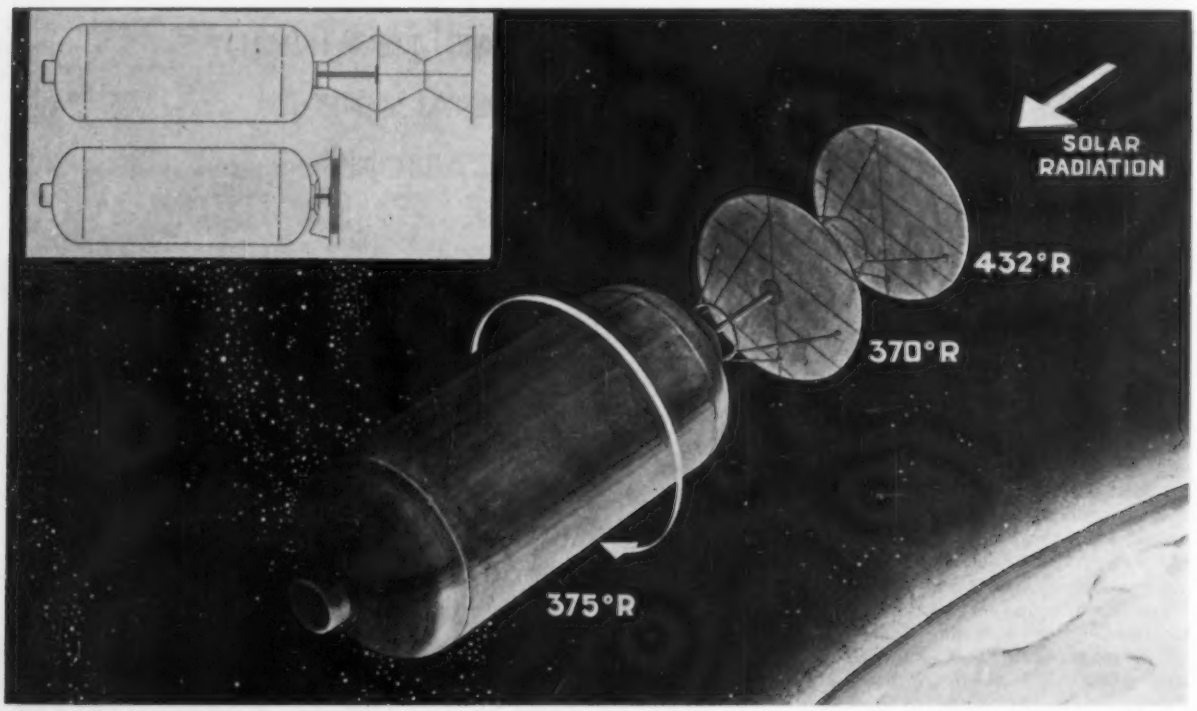
Albedo is solar energy scattered and reflected from earth and earth's atmosphere. Its intensity is about 36% that of direct solar radiation. Albedo has the same wavelength distribution as direct solar radiation; the surface properties needed to reflect the latter will handle the albedo.

Earth infrared is direct radiation from the earth having approximately 18% the intensity of direct solar radiation. Protection against this type of heat presents some problems because of its wavelength. Surface properties resulting in low-equilibrium skin temperatures when subjected to solar and albedo are also good absorbers of earth's infrared.

• **Non-vented approach**—Tank configuration was assumed to be cylindrical, although Olivier and Dempster say a spherical chamber is the optimum shape. The cylindrical tank was chosen because the investigation was based on the *Saturn C-2* payload capability.

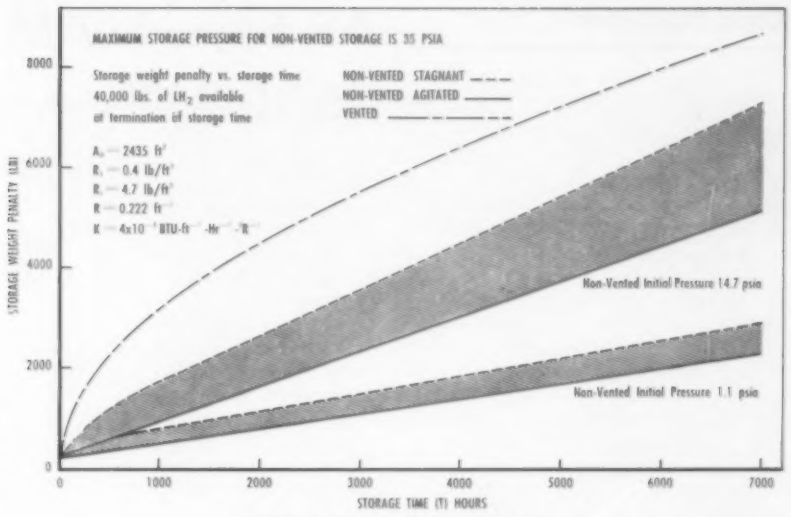
In addition, superinsulation is assumed, along with negligible effects from aerodynamic heating and initial ullage. Basic storage methods include vented, non-vented and a combination of the two.

Vented or constant-pressure systems are currently the most popular concept of orbital or deep-space storage methods. With such a system, however, a reliable zero-g vent method is necessary



HEAT SHIELDS are most effective if there are no planets in the vicinity and main source of heat flux is solar radiation.

Established



Storage Method Comparison

and an additional initial fluid weight is required if a specific quantity is to be available at the end of the storage time.

Olivier and Dempster say that three factors present in orbital storage, but not applicable to ground operations led to the study of non-vented or constant volume storage:

—Propellant cost is no longer dictated by production cost. The pricetag from launch pad to orbit determines the propellant cost. This applies not only to the stored propellant, but also to hardware such as insulation, tanks, and transfer lines.

—The mass of stored propellant does not change with time in non-vented storage. This eliminates the necessity for propellant mass determination at the end of storage, just prior to use.

—Non-vented methods eliminate the need for zero-g venting.

The combined concept could be employed to prevent storage tank rupture if the allowable non-vented storage time is exceeded for any reason.

In comparing the two basic systems, Olivier and Dempster found that the sub-cooled non-vented concept shows a decided advantage over both the vented and normal (not sub-cooled) non-vented methods. A very small weight penalty is involved between stagnant and agitated conditions.

Fluid agitation has a great influence on storage time, but because of the difficulty in predicting the degree of agitation, the NASA experts based all calculations on stagnant conditions—resulting in conservative storage time figures.

The normal non-vented concept has a weight penalty between the vented and sub-cooled non-vented, and exhibits a large difference in weight penalty between the stagnant and agitated conditions.

The vented concept has the highest storage weight penalty for the storage times covered in the study. For extremely long storage periods, the vented curve will eventually cross all of the non-vented lines as graphed. Olivier and Dempster consider this to be of only academic interest, because of extreme insulation weight. A trade-off exists where the excess insulation weight exceeds the weight of the on-board refrigeration system.

• **External protection**—Shadow shields were investigated to determine their effectiveness on the overall storage time of a propellant tank in a 300-mile orbit. Such shields are placed between the tank and the source of incoming radiation.

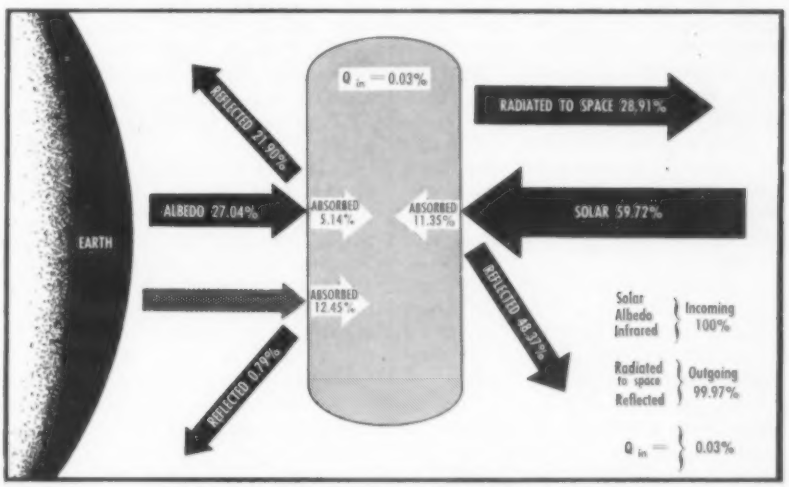
The initial study conducted on shadow shield applications showed Oliver and Dempster that the principle was impractical for bodies in low geocentric orbits. To be efficient, shielding also must be provided against earth albedo and earth's infrared—and this shielding must be continuous.

For the shadow case studied, a tank equilibrium skin temperature of 375° R was obtained. This represents only a 45° reduction from the unshielded tank oriented with its axis perpendicular to solar radiation and slowly rotated about its longitudinal axis.

The lower skin temperature of the shielded tank results in a smaller heat input and thus, a longer storage life—about 5-10% of total storage time. The NASA experts feel that the weight requirements for the shields and orientation mechanism could be more practically traded off by adding more insulation.

Olivier and Dempster conclude that the storage of liquid hydrogen, or any other cryogenic liquid, in a geocentric orbit or beyond in a vented tank is uneconomical and unnecessary. For very short periods, up to two years, the non-vented method will do. For very long storage periods, the LH_2 must be sub-cooled before launch.

In view of this requirement, it is recommended that a study be made of ground support equipment needed for liquid hydrogen subcooling—evaporation, helium-bubbling or refrigeration methods. ¤



Thermal Balance for Orbital Storage

Cape Expansion

(Continued from Page 15)

vertical position.

The booster will be moved well over a mile to the launch pad, a combination journey on a specially built canal and tracks over which a barge will travel.

• **Cyrogenics Facility**—While it is likely that this building will be used to manufacture liquid hydrogen, oxygen, and nitrogen, no final decision has been made. It is certain, in any case, that such a building will be needed to store the propellants.

Whether it will be used for production will be decided when there is firm information on the rate at which the big boosters will use up the propellants at launch time. Preliminary studies indicate that they will have to be manufactured close by to insure that they are fresh at launch time. ⌗

• **Apollo spacecraft building**—This will be used to assemble and check out the spacecraft, and will be a sharp improvement over current building used to check out the *Mercury* capsule. For one thing, the new building will have proper air conditioning control to insure proper operation of the spacecraft. It will also feature air locks to keep it completely dust-free, excellent humidity control, and sufficient shielding to prevent radiation from seeping in from outside.

• **Nova Control Blockhouse**—This will be built about a half mile from the launch pad. Because the vehicle will be assembled on the pad, no special building is needed.

• **Bio-Medical building**—This will be used to insure "good crew readiness" and also for performance of extensive physical and mental tests on crew members after missions are completed.

Space agency officials admit that quite a bit of dredging and earth filling will have to be done, principally in the launch pad area. They note that contrary to common belief, no major bridges will have to be built.

The large highways running through the Cape will be enlarged to four lanes, and it is expected that another causeway will be built either by local or state officials to connect Canaveral with Orlando.

Officials also said that while basically the present tracking facilities will be used, some beefing up will be needed to provide tracking adequate for Project *Apollo*.

One certain result is that several more Navy ships will be outfitted for NASA tracking and recovery missions. Much more use will also be made of closed-circuit television. ⌗

AF Says SLAM Would Cost $500 Million to Flight-test

SOME $500 MILLION would be required to carry the *SLAM* (supersonic low-altitude missile) program through the flight-test stage—$400 million of it Air Force money and the remainder from the Atomic Energy Commission.

That cost estimate for the nuclear-powered ramjet vehicle was given to the Joint Committee on Atomic Energy last week by the Air Force.

Col. Ola P. Thorne, asst. deputy chief of staff, research & technology for atomic energy, said the Air Force Fiscal 1962 budget contains $7 million for *SLAM*, under development at Chance Vought (airframe), Marquardt Corp. (engine), and Lawrence Radiation Laboratory (reactor). Of this amount, he said, Department of Defense has released only $1½ million to the Air Force. The AEC budget contains some $30 million for the *Tory* and *Pluto* propulsion test programs leading to *SLAM*.

Chance Vought is known to have put about $2½ million of its own money into the program.

Dr. Harold Brown, DOD director of research and engineering, told the committee that DOD has not yet formulated plans to utilize the capabilities of such a vehicle. He said an ad hoc committee now is studying the program.

The committee has held one series of meetings during which visits were made to Chance Vought, Marquardt and LRL. Another meeting is set for Sept. 12.

"It is hoped that a final report will be completed by the end of September," Dr. Brown said.

• **Genesis**—He told the committee that as a result of early work with the AEC, starting in 1955, on feasibility of a nuclear ramjet, the Air Force initiated studies with North American, Convair and Chance Vought, amounting to $200,000 each (M/R, March 28, 1960, p. 14).

"The Air Force made an evaluation of the three proposals and concluded that the most attractive of these proposals was submitted by the Chance Vought Corp.," Dr. Brown reported.

He said Chance Vought then continued with its own funds to develop a detailed study of the problems associated with building and operating a nuclear-powered, ramjet low-altitude bomb delivery system. At the same time, Air Force asked its Systems Command to submit a preliminary development plan delineating the high-risk technical areas.

The Systems Command, noting that the propulsion system was yet to be satisfactorily demonstrated, recommended that any firm commitment on a low-altitude nuclear system be held up pending results of the *Tory II* series of tests.

At about the same time, Dr. Herbert York, then DOD research and engineering director, set up an ad hoc committee under William Littlewood of American Airlines to evaluate the nuclear ramjet. That committee, according to Dr. Brown, came to these conclusions:

1. Since the most critical element in the *SLAM* system is the reactor, adequate reactor performance should be demonstrated in order to resolve the major uncertainty of the program.

2. Development of all elements of the *SLAM* program at that time (October, 1959) would be premature.

3. Current emphasis on *Pluto*, the engine program, seemed adequate.

Dr. Brown reported that in June, 1960, the Air Force Chief of Staff decided that, because of the high-risk technical areas remaining, the program should be oriented toward subsystem development until risks and costs were more clearly defined.

The program has continued along that line during the past year, Dr. Brown said. The AEC has continued with its *Tory* reactor development and testing, with the Air Force funding programs at Chance Vought and Marquardt on ramjet components and the airframe.

Success of the *Tory II A* test in Nevada on May 14 led to further reviews by DOD and the Air Force.

According to Col. Thorne's testimony, the Air Force has suggested to the new ad hoc committee that an additional $23.4 million is required now to step up the *SLAM* program. He said also that considerably more than this has been requested in the Fiscal 1963 Air Force budget package which has been presented to DOD.

Col. Thorne told the committee that Air Force studies have indicated that nuclear ramjet propulsion is technically feasible.

"However," he said, "we feel that one cannot as yet define a specific system requirement, since the weapon system program risk and probable cost cannot be sufficiently delineated at this time."

He said an expanded program of ground-testing would appear to be logically the next major technical step. ⌗

Honeywell Adding to Inertial Guidance Plant

MINNEAPOLIS-HONEYWELL has begun construction of an addition to its St. Petersburg, Fla., inertial guidance facility. The $550,000 addition is being built to meet increased engineering development and production efforts, the company said.

Programs currently under way at the plant include production of inertial guidance systems for *Centaur*, development of the primary and secondary guidance systems for *Dyna-Soar*, production of inertial components for *Polaris*, development of an inertial guidance system for *Saturn*, and a number of classified programs.

DYNALECTRON CORP. established a new subsidiary, Data Analysis Corp., with headquarters in Washington, D.C.

President of the new subsidiary is William S. Shoaf, former manager, RCA's Defense Products Div.

The new subsidiary is the firm's latest expansion in the field of automatic data analysis, handling and processing.

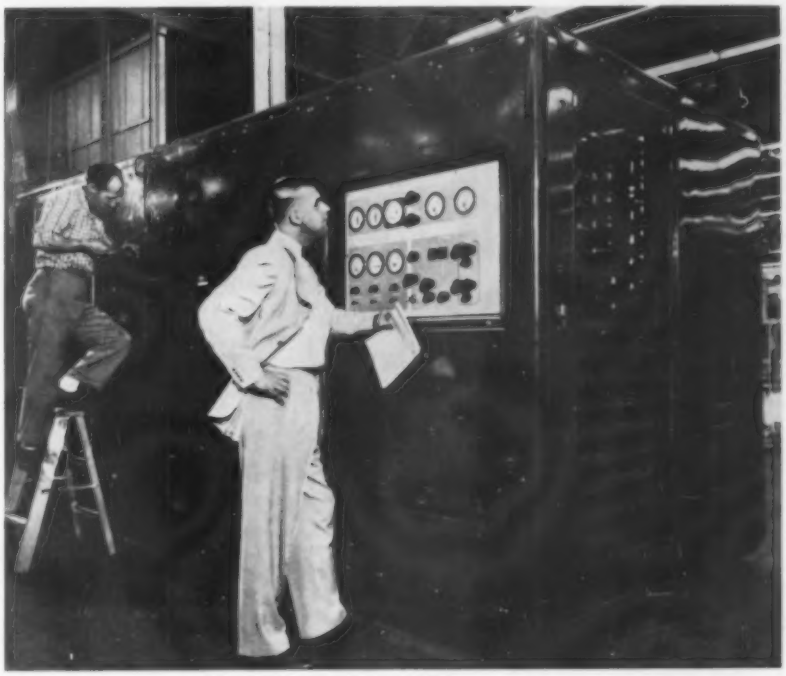
LEESONA MOOS LABORATORIES, a division of Leesona Corp. is the new name of Patterson Moos Research Div. of Leesona Corp. Leesona's President said "The new name better defines our operations in advanced scientific areas, such as energy conversion at . . . Jamaica, Long Island, as distinct from our R&D work on new textile machinery. . . ."

SYSTRON-DONNER CORP. has acquired Greenleaf Manufacturing Co., St. Louis, producer of gyroscopes.

Greenleaf will be operated as a division of S-D, which produces electronic instrumentation, computers, transducers and flight control devices for such programs as *Mercury* and *Polaris*.

GENERAL PRECISION, INC. Kearfott Div., has established the Kearfott Research Center to expand the company's work in improvement of product lines, and provide information in new product areas. Facilities will be located at West Paterson, N.J.

AIRTRONICS, INC. dedicated its new $1.5-million facility in Bethesda, Md. The plant was specifically designed and built to meet government regulations for handling classified projects.



Temperature Control for Titan Fuel

FINAL CHECKOUT and assembly is made before delivery of the first temperature control unit for Titan II liquid fuel. The units are made by Hamilton Standard Div. of United Aircraft Corp. and will be installed near fuel storage tanks at the missile sites.

UNISTRUT PRODUCTS CO., Chicago, has established a Clean Room Division to design and build fcailities to meet customer requirements and coordinate purchase and installation of all integral equipment and machinery.

MESA PLASTICS CO., Los Angeles, has established a Long Island plant to service the East and Midwest. Mesa produces thermosetting molding compounds. Products range from encapsulated resistors, electrical connectors, to missile nose cones.

POLYMER CORP., Reading, Pa., has put in operation a newly remodeled lab designed for plastic product research and pilot plant development. Among the special fluorinated thermoplastic compostions developed by Polymer are a variety with controlled electrical properties for anti-collision devices and special missile applications.

Financial Reports

COMPANY	PERIOD	INCOME		EARNINGS	
		1961	1960	1961	1960
Amphenol-Borg Electronics	6 Mo. June 30	$ 34,641,054	$ 35,225,005	$ 463,470	$ 1,532,948
Atlantic Research Corp.	6 Mo. June 30	9,039,071	5,985,215	606,035	
Coleman Engineering Co.	year, April 30	4,577,543	4,805,692	133,199	—552,427
Control Data Corp.	year, June 30	19,783,745	9,665,290	842,524	551,686
Ling-Temco Electronics	6 Mo. June 30	70,847,881	76,120,336	827,379	1,437,076
Parker-Hannifin Corp.	year, June 30	50,902,464	50,711,631	2,797,183	2,873,537
Sperry Rand Corp.	3 Mo. June 30	265,823,716	291,761,602	4,296,313	5,410,579
U.S. Industries	6 Mo. June 30	44,647,000	51,026,000	1,176,000	3,000

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contracts

NASA

$250,000—**Blaw Knox Equipment Div., Blaw Knox Co.**, Pittsburgh, for a second-phase feasibility study concerning a 240-ft.-diameter space tracking antenna.

DOD

$92,330—**Geophysics Corp. of America**, Bedford, Mass., for a theoretical study of debris motion following high-altitude nuclear explosions.

MISCELLANEOUS

$300,000—**Telecomputing Corp.**, Los Angeles, from **Autonetics Div., North American Aviation** and **Nortronics Div., Northrop Corp.**, for *Minuteman* and *Skybolt* cooling systems.

$60,000—**Epsco Instruments, Div. of Epsco, Inc.**, Cambridge, Mass., from *GE's Missile and Space Vehicle Dept.*, for a militarized, four-decimal-digit, analog-to-digital converter for use as part of ground support equipment in Project *Advent*.

NAVY

$185,000—**American Machine and Foundry Co.**, Greenwich, Conn., for development of an advanced mobile photographic tracking mount system.

$110,000—**The Boeing Co.**, Wichita, Kan., from ONR, for a study of physiological reactions to varying degree of vibration.

ARMY

$1,400,000—**Bendix Corp., Bendix Systems Div.**, Ann Arbor, Mich., for a communication package for *Advent* program.

$1,200,000—**Adler Electronics**, New Rochelle, N.Y., for production of three AN/TSC-18 air-transportable communications systems.

$180,000—**Electronic Defense Laboratories, Sylvania Electric Products, Inc.**, Mountain View, Calif., for study and analysis of specific electronic warfare techniques.

General Electric's Tube Dept., Owensboro, Ky., for designing and determining the feasibility of producing a tube-cavity combination to serve as an X-band local oscillator. No amount disclosed.

AIR FORCE

$10,576,765—**Chrysler Corp.**, Detroit, for installation and checkout of the *Jupiter* IRBM.

$1,577,102—**Hughes Aircraft Co.**, Culver City, Calif., for GAR-4A *Falcon* missiles, shipping and storage cases, and empty warhead cases.

$1,500,000—**The Martin Co.**, Baltimore, for production of TGM-83, trainer model of *Bullpup* missile.

$1,096,700—**The Martin Co.**, Baltimore, for storage and distribution of tactical missile weapons system (*Mace* and *Matador*).

$957,940—**Melpar, Inc.**, Falls Church, Va., for seven *GAM 83 A/B* missile trainers.

$900,000—**Northrop Corp.'s Nortronics Div.**, Anaheim, Calif., from **The Boeing Co.**, for penetration rocket launchers for use on SAC's B-52H ballistic missile bombers.

$758,929—**Defense Products Div., Fairchild Camera and Instrument Corp.**, Syosset, N.Y., for new projection viewers for the screening of high-resolution photography.

$500,000—**The Johns Hopkins University**, Baltimore, for research directed toward high-altitude astronomical observations.

$300,786—**General Atronics Corp.**, Bala-Cynwyd, Pa., from Ballistic Systems Div., USAF, Los Angeles, for a theoretical and experimental program to establish the feasibility of an advanced technique for detection of objects in space.

$225,000—**Microdot, Inc.**, Pasadena, Calif., from **Philco's Western Development Labs.** for UHF narrow-band data link transmitters and subassemblies for *Midas* missile alarm satellites.

$40,671—**Aerojet-General Corp.**, Azusa, Calif., for services necessary to an *Aerobee* attitude control system gas-dispersion investigation.

ARPA R&D

Advanced Research Projects Agency, The Pentagon, Washington 25, D. C.

Research and Development Sources Sought.

Major Research and Development Projects currently assigned to the Advanced Research Projects Agency (ARPA) include the following:

Advanced Ballistic Missile Defense-Project Defender. The purpose of this project is to increase technical knowledge in the appropriate scientific fields and techniques which are necessary to establish a technical formulation for the development of advanced defenses against exo-atmospheric offensive vehicles including space vehicles and ballistic missiles. The Defender Project is subdivided in four major areas: (1) General Research which includes missiles physics research, nuclear effects research, atomic and molecular physics research, radio frequency research and research pertaining to charged particle beams; (2) Techniques and Devices which include sensors, over-the-horizon detection, interception and kill mechanisms; (3) Missile Phenomenology, concerned with developing a thorough understanding of the phenomena which occur throughout ballistic missile flight from launch through re-entry; (4) Systems Area pertains to investigations conducted to establish feasible approaches which can provide an acceptable level of ballistic missile and space vehicle defenses at reasonable cost.

Nuclear Test Detection-Project Vela. The Vela Project consists of programs of research, experimentation and systems development for improving the detection of nuclear explosions both underground and at high altitude. It is subdivided into three major programs: (1) Vela-uniform program is involved with improvements in seismological and other geophysical techniques for detecting underground tests; (2) Vela-Sierra program is concerned with techniques for the detection and identification of high-altitude detonations by means of equipment located on the earth's surface; (3) Vela-hotel program includes development of surveillance equipment installed on space vehicles for detecting nuclear detonations above the sensible atmosphere.

Basic Research in Materials-Project Pontus. This project involves research, experimentation, and development to obtain major improvement in materials required to meet the needs of the surface, air, or missile programs. Programs include metallurgy, ceramics, solid-state physics, inorganic chemistry, polymer science and phenomenological studies of materials behavior.

Advance Propellant Chemistry-Project Principia. Research leading to solid, liquid, and hybrid propellants having specific impulses appreciably higher than those now available. Research includes thermodynamics and thermo-chemistry, synthetic chemistry and propellant formulation and evaluation.

Toxicology Research-Project Tores. A research project to acquire basic knowledge of the health hazards of new non-tactical chemical products to insure safe, efficient, and economical handling. These are primarily utilized in new fuels, propellants, coatings, solvents, explosives and lubricants.

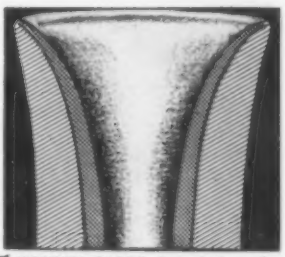
Advanced Energy Conversion-Project Lorraine. An advanced research program involving the fundamental aspects of energy conversion in the following categories: thermionics, thermoelectrics, electro-chemistry, magnetohydrodynamics and ancillary studies.

Booklets describing these and other projects in greater detail, and outlining procedures for submitting proposals, may be obtained from the Advanced Research Projects Agency, The Pentagon, Washington 25, D. C.

example...

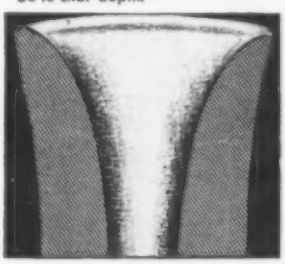
FIBERITE

INSULATION AT WORK IN POLARIS



FIBERITE 2630A formulation of graphite reinforced phenolic ... 30% char depth.

Char Depth



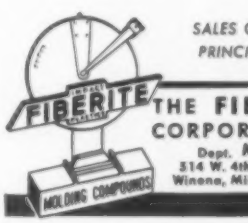
Standard graphite reinforced phenolic 100% char depth.

The development of special Fiberite MX 2630A formulations reduce char depth of graphite reinforced phenolic molded insulations up to 70%, thus permitting the use of these materials in more critical solid propellant rocket motors.

Cut-away sections above illustrate reduction of char depth by utilizing Fiberite molding material.

EXPLORE FIBERITE

Missile engineers will find our research helpful in solving problems requiring materials for special performance. Write factory for bulletin "Fiberite High Temperature Insulating Materials."



SALES OFFICES IN PRINCIPAL CITIES

THE FIBERITE CORPORATION
Dept. MR-7
514 W. 4th Street
Winona, Minnesota

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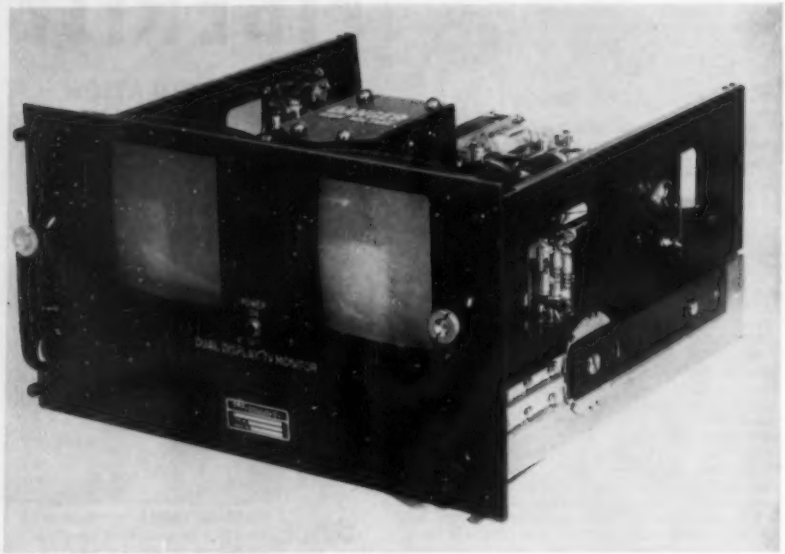


Dual-Display TV Monitor

Two fully transistorized MIL Spec TV monitors on a single 10½-in.-high rack-mounted chassis are being marketed by RMS Associates, Inc. The dual-display TV monitor, Type M20002, feature two 5½ in. x 5½ in. presentations. Conventional 3:4 aspect ratios are also available. Two independent 5.5 mc video amplifiers and two independent horizontal deflection amplifiers are used. The vertical deflection amplifier is common for both monitors. The unit is especially suited for installation in ground or air-transportable monitoring stations where ruggedness and reliability are important.

Circle No. 225 on Subscriber Service Card

Intensity Meter

Empire Devices, Inc. is marketing a tuning unit which extends the range of the widely-accepted Noise and Field Intensity Meter, Model NF-105, downward to 14 kc, thus providing continuous coverage from 14 kc to 1000 mc. Designated Model T-X/NF-105, this tuning unit is compatible with all existing NF-105 basic units. Tuning from 14 kc to 150 kc is provided in three ranges: 14-25 kc, 25-62 kc, and 62-150 kc; nominal bandwidth is 1 kc and full-scale sensitivity of 0.1 microvolts. Available as accessory items are a 36-in.-diameter loop antenna, a 41-in. vertical antenna, a line probe and a carrying case.

Circle No. 226 on Subscriber Service Card

Waveguide Ferrite Isolator

Three compact waveguide isolators are available from the Motorola Solid State Electronics Department for use at J-Band (5.80—8-200 kmc), X_N Band (8.200—12.400 kmc) and X_L Band (7.050—10.000 kmc). These devices are transverse-field, resonance-absorption isolators, each designed to maximize load isolation, maintain low insertion loss, and hold VSWR to a low level. Designated Models J103, X103, and XL102, respectively, the J-Band, X_N-Band, and X_L-Band isolators exhibit typical performance characteristics of 30 db minimum isolation, 1.0 db insertion loss, and 1.15 maximum VSWR over the specified operating frequency band.

Circle No. 227 on Subscriber Service Card

Microwave Swept Oscillator

Sperry Microwave Electronics Co. is marketing Microline (TM) Model 64 1 microwave swept oscillator series. The sweep may be from low to high, or high to low frequency, and the end points are independently adjustable over the entire frequency range. Sweep rates are continuously variable in four ranges from 0.01 to 100 sec. There is provision for external sweep and d-c coupling to permit frequency programing.

Circle No. 228 on Subscriber Service Card

IR Pyrometer

A compact infrared industrial pyrometer (no larger than a hand movie camera) is available from the Servo Corp. of America. The pyrometer is designed to cover the industrial infrared wave-length spectrum of from 1-12 microns. Because of its high sensitivity and fast response, the pyrometer can measure and control the temperature of an object of any size, whether the target is stationary or moving at various speeds. Its sensitive infrared eye watches the target from a remote position, providing complete safety for personnel.

Circle No. 229 on Subscriber Service Card

Germanium Expitaxial Mesas

A series of six germanium epitaxial mesa transistors, claimed to supplant virtually all germanium mesas, micro-alloy and other transistor types currently used for high-speed switching applications, has been announced by Motorola Semiconductor Products Inc. The units combine greatly improved switching characteristics with drastically reduced prices, and replace transistor types currently in use. Housed in the

TO-18 package, the units are designed with optimized physical geometry for high-speed switching applications in both high- and low-current circuits, eliminating the need for different transistor types in systems encompassing various design configurations and permitting greater standardization of components and smaller inventories.

Circle No. 230 on Subscriber Service Card

Microwave Pulse Generator

A MPG-3 microwave pulse generator producing nonosecond pulses at gigacycle frequencies from conventional radio frequency signal generators is available from the Hallicrafters Co. The MPG-3 can also serve as a self-contained wideband traveling-wave-tube amplifier or as a serrodyned amplifier for frequency translation. The MPG-3 is available in six bands—UHF, L, S, C, X and KU—covering the microwave spectrum from 0.5 to 18 gc/s. Both pulse widths and pulse repetition rates can be precisely adjusted. Pulse widths range from 0.03 to 500 microseconds and pulse repetition rates can be varied from 2 to 50,000 pulses per second. Power output is 10 milliwatts.

Circle No. 231 on Subscriber Service Card

Conductive Plastic

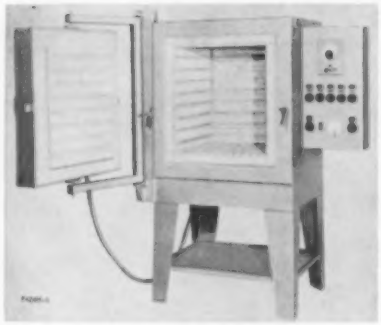
A plastic material developed by Mesa Plastics Co. has very nearly ideal conductive properties in direct contradistinction to the normal conception of plastic materials. A 3-volt bulb, powered by two 1.5-volt batteries wired in series with a probe and a bar of the plastic material, will light no matter where the probe is applied to the bar. Applications include waveguide, RF connectors and electronic components. Pilot uses of the material have found it particularly well adapted to the production of printed circuits where a flush surface is desired.

Circle No. 232 on Subscriber Service Card

Temperature Sensor

An immersion-type resistance temperature sensor with a 0.2 second time constant has been introduced by Rosemount Engineering Co. The sensing element of th eREC Model 176 is protected by a stainless steel well. Temperature range covered is from −435°F to 500°F. The fast response for a temperature sensor of this type is achieved by a unique design in which a strain-free element is mounted directly on the inner wall of the well. The Model 176 was designed for storable fuel applications in the missile field, but is suitable for use in any part of the stated temperature range and in any fluid compatible with the stainless-steel material of the well.

Circle No. 233 on Subscriber Service Card



High Temperature Furnace

The L & L Manufacturing Co. has produced a small, compact furnace which heats up to 2000°F in one hour; 2300°F in one and a half hours. A constant level of temperature and infinite heat-rate control ranging from 300°F to 2300°F can be maintained by means of input controllers. These can be set at from 7% to 100% of input. Zone gradient control operates by multiple circuits, with each circuit having its own input controller. Gradients are indicated by a pyrometer and two thermocouples, located zonewise, and a thermocouple selector switch. Fully automatic temperature controlled units are also available. Each unit can be equipped with forced convection fans to assure an automatic and even gradient in the furnace at any point along the heat curve.

Circle No. 234 on Subscriber Service Card

Metal Bellows

Metal bellows and bellows assemblies, supported and unsupported, made by advanced methods to achieve dependability under critical operating conditions, are available from Avica Corp. Bellows are individually designed for use as pressure seals, flexible joints or vibration dampeners in gas or liquid transmission lines subject to high pressure or vacuum and temperature extremes. Available in sizes from 1 in. to 12 in. ID, the bellows are made in stainless steel and other metals in either developmental or production quantities.

Circle No. 235 on Subscriber Service Card

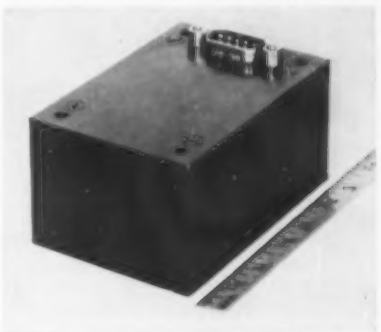
Electrohydraulic Actuator

The Annin Co. is marketing a 20,000 Series electrohydraulic actuator which offers extremely fast speed, high frequency response, good positional accuracy and large thrust. Custom-designed for specific applications, the actuator, designated Model EHA-1, provides a means of converting a suitable electrical signal from an automatic or manual electrical control station to a powerful hydraulic force. The actuator is responsive to minute rapid changes in electrical signals and delivers instantaneous action while remaining inherently stable under adverse operating conditions.

Circle No. 236 on Subscriber Service Card

D-C Amplifier

International Data Systems has developed a silicon transistor chopper d-c amplifier with differential isolated input. All circuits, including the chopper and synchronous demodulator, utilize silicon transistors in order to allow operation from −20° to 100°C and also to withstand missile environment with respect to shock and vibration. Full-scale input voltage is ±10 mv (maximum gain) to



+250 mv (minimum gain). Full-scale output signal is ±5 v and is completely balanced and isolated from ground. Frequency response is 0 to 3 kc. Stability is ±2% of full scale, with linearity of 1% of full scale. Gain is continuously adjustable from 20 to 500.

Circle No. 237 on Subscriber Service Card

Hydraulic Load Simulator

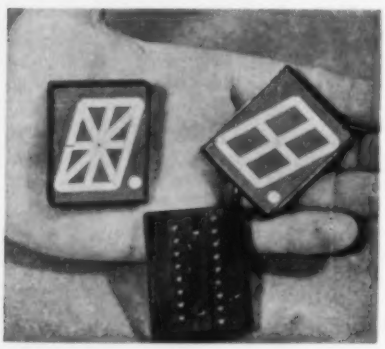
A 10-channel hydraulic load simulator, capable of accurately delivering up to 500,000 lbs. per channel, is available from Gilmore Industries, Inc. The simulator control console contains all the measuring and control components for 10 independent channels of hydraulic force control. Each channel uses a load cell transducer coupled to a hydraulic cylinder. A force on any cell will cause an unbalance of the strain-gage bridge within the cell, resulting in a voltage signal proportional to the force. The

control console receives this signal and compares it with a "command" signal controlled by the operator. Any difference in signal is detected by the servo amplifier, and a correction signal is sent to the four-way servo valve which will vary the hydraulic pressure at the cylinder.

Circle No. 238 on Subscriber Service Card

Read-Out Panels

Reliable electroluminescent panels for the display of numeric and alphanumeric information have been developed by Sylvania Electric Products Inc. The 1½-in. panels, designated AN-150 and NU-150, are composed of segments of electroluminescent lamps insulated from one another and individually terminated. Type AN-150 has 14 segments that produce the complete alphabet, 0-to-9 numerics, a decimal point, and other mathematical symbols. Type NU-150 consists of nine segments which produce a display of 0-to-9 numerics, a decimal point, and selected mathematical symbols. Below the panel



is a rear view of the base used on both devices. The basic design and structural simplicity of the display devices and panels offer the advantages of minimal catastrophic failure, high reliability, long life, simplified circuitry, negligible power requirements and compactness.

Circle No. 239 on Subscriber Service Card

Coaxial Mechanical Switch

E&M Laboratories has available a microwave coaxial mechanical switch. The switch has been designed to withstand the extreme environments of modern missiles. Ruggedness for durability against shock and vibration, and capability to operate in temperatures up to 300°F, have been combined with minimal size. Standard units cover the frequency range of 0 to 6 kmc, and switch in a nominal operating time of 10 milliseconds. The actuator requires approximately 8 watts of power.

Circle No. 240 on Subscriber Service Card

Cryogenic Valves

Hardened seats for longer life are featured in the new Hydraulic Research miniature cryogenic valves designed for missile applications. The valves—production items—range from 100 psi to 4000 psi in capacity, and operate dependably in a temperature range from −425°F to 300°F, according to the manufacturer, with an extremely low degree of internal leakage. Functional tests using 1000 actuations at various temperatures showed zero leakage in the 70°F range with leakage as low as 0.5cc at −300°F at 3000 psi.

Circle No. 241 on Subscriber Service Card

Scratch Gage

Bausch & Lomb is marketing a scratch-depth gage which measures scratches, grooves and other indentations on flat or curved surfaces with high speed and accuracy. Because of its ease of operation and portability, the new gage provides a precise, inexpensive and non-destructive means for determining whether such surface indentations fall within prescribed limitations. It works equally well for measuring raised portions of workpieces. Highly precise measurements to an accuracy of ±0.0001 in. or 5% of the depth, whichever is greater, can be made for indentations with depth of from 0.0002 to 0.016 in.; widths from 0.001 to 0.050 in. can be determined to ±0.001 in. The same range applies to the measurement of raised portions. In addition to depth and width measurements, the gage clearly shows the contour of the indentation.

Circle No. 242 on Subscriber Service Card

Photoelectric Modulators

A low-impedance line of Photoelectric Modulators or "Choppers" has been developed by Cambridge Electronics Corp. These units, designated M10L and M20L, are designed to match circuit impedances of 1.5 K-ohms, and offer either SPST or DPST switching action, respectively. Being non-mechanical in nature, they are not hampered by contact wear or non-ohmic conduction effects, and create no vibration in other circuit elements. Carrier feedthrough is less than 1 uv. Operating life exceeds 5000 hours. Modulation frequencies up to 1 KC are possible.

Circle No. 243 on Subscriber Service Card

Pulse Amplitude Shaper

Franklin Systems, Inc. has designed and produced a pulse amplitude discriminator and pulse shaper whose input is suitable for operation from pulse amplifier and special pulse circuits. The output is utilized for analog integrating circuits (with meter or recorder) as well as digital counters and oscilloscopes. This completely transistorized plug-in unit will fit in the palm of a hand.

Circle No. 244 on Subscriber Service Card

Magnetic Field Detector

A sensitive detector, Model 501, capable of measuring d-c magnetic fields as low as one-quarter gauss, has been announced by the Halltest Divi-

sion, Instrument Systems Corp. The instrument may be used in the measurement of the earth's magnetic field, fields in the vicinity of scientific installations, determination of strength and orientation of magnetism in critical ship and aircraft structures. Based on the Hall-Effect principle and utilizing high-gain Siemens Hall generators, the unit operates without amplifiers and provides a center-to-full-scale deflection of 0 to 5 gauss. Compactness achieved through simplified design and power requirement of only one mercury cell permits the instrument to be held with one hand. Size is 5¼ in. x 3 in. x 3 in.

Circle No. 245 on Subscriber Service Card

names in the news

BLAIR

CLARK

BINGHAM

ROMIG

CHILTON

Dr. Finn J. Larsen: Appointed Assistant Secretary of the Army for Research and Development. Dr. Larsen previously was associated with Minneapolis-Honeywell Regulator Co. as vice president in charge of research, and from July 1961, has served as consultant for Research and Development to the Secretary of the Army.

Evan Noonan: Chief of the Propellant Division for the Chemistry and Explosives Research Dept., White Oak Naval Ordnance Laboratory, died August 23 of a heart attack. With the Laboratory since 1949, Noonan was an authority on rocket fuels, helping to coordinate interservice developments in this field and to judge the efficiency of systems already in use.

James H. Douglas: Chicago attorney and former Deputy Secretary of Defense, elected a trustee of The MITRE Corp., Bedford, Mass. **Edward Reynolds, Jr.,** elected treasurer of MITRE, filling the vacancy caused by the resignation of **J. J. Snyder.** Reynolds formerly was assistant to the vice president and head of the contract administration department, Canadian Pratt & Whitney, a subsidiary of United Aircraft Corp.

Claude M. Blair: With American Telephone & Telegraph Co. over 30 years, elected vice president with responsibility for the company's satellite communications programs.

Frank D. Banta: Elected assistant vice president and an officer of General Precision, Inc., Tarrytown, N.Y. Banta will continue to serve as director of program management.

V. G. Nielsen: Retired Thompson Ramo Wooldridge Corp. vice president and consultant on the formation of Aerospace Corporation, elected to the board of trustees of Aerospace. **Allen F. Donovan,** senior vice president, technical, of Aerospace Corp., elected to the board of trustees.

Carey Carpenter: Elected executive vice president, Copolymer Corp., Los Angeles. Active in reinforced plastics since 1953, Copolymer will broaden its research and development effort under the former technical manager of Swedlow, Inc.

Paul Gottfried: Joins Booz, Allen Applied Research, Inc., Washington, D.C., as a reliability scientist. Prior to joining BAARINC, Gottfried was a partner in Reliability Engineering Associates, Chicago.

Dr. Neal Zierler: A noted authority on coding theory, joins Arcon Corp., Lexington, Mass. **Dr. Robert W. Sittler,** well-known for his work in sampled data systems analysis and feedback control systems analysis, appointed technical director of Arcon.

Dr. Bernard R. Linden: Promoted to director, Electron Tube Branch, CBS Laboratories, Stamford, Conn.

R. Adm. John E. Clark, USN: Former Commander, Carrier Division 16, Atlantic Fleet, assumes command of the Pacific Missile Range. Adm. Clark relieves R.Adm. Jack P. Monroe, USN, assigned to a newly-established billet as director of Development Facilities in the Office of Chief of Naval Operations, Washington.

Lt. Col. Lee B. Ledford, Jr. (USA-ret.): Appointed assistant to the president, Kollsman Instrument Corp., a subsidiary of Standard Kollsman Industries, Inc., New York City. Until recently, Col. Ledford served as chairman of the Board of Review, Dept. of the Army.

Robert W. Bingham: Named program manager of Fairchild Stratos Corp's new *XE-2* multi-purpose drone project. Previously Bingham has held technical and managerial positions with Western Electric, Aberdeen Proving Ground, Army Chemical Center and U.S. Biological Laboratories.

Dr. Kenneth L. Miller: Appointed head of Applied Mathematics Section, Mathematical Analysis Dept., Computation and Data Reduction Center, Space Technology Laboratories, Inc., Los Angeles. **Jerome M. Schwarzbach** named manager, Systems Engineering Dept., **John T. Blake,** special technical staff assistant, both in *Atlas* program office of STL.

Dr. Harry G. Romig: Previously senior scientist and staff member of Operations Research, Inc., named corporate director of quality engineering, Leach Corp., Los Angeles, with primary emphasis on Relay Division activities.

Robert C. Chilton: Former vice president-development planning, Horkey-Moore Associates, a division of Houston Fearless Corp., joins Space Equipment Corp., Los Angeles, as secretary and contracts administrator.

Donald E. Boren: Promoted to manager, Data Acquisition Planning, Pan American's Guided Missiles Range Division, Patrick AFB, Fla. **John Park** named manager, Data Support Planning.

George Friedl, Jr.: Former vice president and director of operations, Westwood Division, Houston Fearless Corp., elected chairman of the board and chief executive officer, The Matthews Corp., Hawthorne, Calif. Friedl succeeds **Walter H. Girdler, Jr.** who died August 10.

Rudolph Furrer: Joins Lockheed Missiles and Space Co., Sunnyvale, Calif., as special assistant-reliability. Furrer formerly was special assistant to the Director of Defense Research and Engineering for Engineering and Reliability.

J. J. Seidman and C. R. Russell: Named manager and associate manager, respectively, of the Computer Dept., Electronics Div., Space Technology Laboratories, Inc., Los Angeles. **George A. Harter** named study director in the Electronics Div., STL, Los Angeles; **Eldon J. Seagrist,** manager of STL office, Arnold Center, Arnold Air Force Station, Tullahoma, Tenn.

D. J. Harnett: Named vice president and counsel, United Industrial Corp., Los Angeles. Formerly Harnett was assistant general counsel at Telecomputing Corp.

Arnold Pollack: Former head of environmental test and design at Airborne Instruments Laboratory, appointed general manager, Aerotest Laboratories, Inc., Deer Park, L.I., N.Y.

letters

Blimps for Mercury

To the Editor:

Let me congratulate you on your excellent article, "Mercury Rescue: Mission for Blimps," by William E. Howard (M/R, Aug. 7, page 17). It is eminently sound in substance and well phrased, on a subject of high national importance.

T. G. W. Settle
Vice Admiral, U.S. Navy, Ret.
Washington, D. C.

Finds Us Helpful

To the Editor:

Congratulations on putting out such a splendid rundown on missiles and rockets, especially in the Fifth Annual World Missile/Space Encyclopedia (M/R, July 17).

As a newswriter (Civil Service title, not mine) for this command, which is steadily getting into the Space Age scheme of things, I find your magazine invaluable. We call it the "Space Age Bible" hereabouts.

As a father of seven, many teenagers among them, it would seem to me that your magazine would be a boon to many high schools and colleges, not to mention the military service schools, etc.

I am a retired Navy chief (30 years) working for the Air Force, writing much Space Age copy. Until I discovered M/R, much of this writing was a chore. Now it's a pleasure, thanks to you and your staff, which puts out such good dope.

Mike Lynch
Information Office
Hqs Sacramento Air Materiel Area
McClellan AFB, Calif.

Hungry for Facts

To the Editor:

Apologizing for intruding upon you, I beg to inform you as follows:

My name is Fabio M. Berto, and I am 20 years old. About five years ago, I was forced to discontinue my regular course of studies and take up a job, owing to my family's economic circumstances. But, because my love for studying is very great, I employed all my free time perusing my books on mathematics, physics, chemistry and astronautics, with the help of my father, Mr. Luigi R. Berto, who in his time attended schools of the highest order and had been an astronautics pioneer in Europe—taking up as early as 1929 the study of space flight. . . .

About three years ago, the economic situation of my family had improved, making it possible for my father and me to devote more money and time to astronautics.

In August, 1958, my father delivered a lecture on Italian television, presenting models of rockets as well as photographs of space. In November, 1959, the Astronautics Sciences and Space Technology Diffusion Center was founded, with my father as President and I as General Secretary. In June, 1960, the Diffusion Center started a free correspondence course, *the first and unique of its kind in the world,* dealing with all problems related to space travel. The number of memberships is now impressive.

Furthermore, my father devoted much of his leisure time to writing articles and stories for newspapers, books and magazines, while I planned and launched many solid-propellant rockets, attaining in March last an altitude of about three-thousand meters.

Since ours is a non-commercial, non-profit organization, it is poorly equipped and lacks the means for actively promoting the development of an astronautical consciousness in Europe.

Hence, I take the opportunity to address this letter to you to ask for material or moral help, which as you know is very difficult to obtain here in Europe. I should be much obliged if you can tell me where I can address questions about U.S. astronautical developments, because the United States Information Services (USIS) has long been without such information.

In fact, in May, 1960, under the auspices of the Italian Consul General, Dr. Guido Zecchin, we delivered a series of astronautical lectures in Yugoslavia on which we received the warmest congratulations. But the USIS in Trieste was unable to supply photos, films or fact-sheets on astronautical subjects, and we found it necessary to show *American developments through use of Soviet books and newspapers, as shown in the photocopies attached.*

вые создания станций уже существующих ракет.

Так, например, К. ле 1958 г. предложил станцию с помощью баллистических раке «Атлас» (рис. 97) явля чатой». Она имеет три шевый (средний) с тяг товых (боковых), кажд три двигателя шарни включаются одновреме двигатели, окончив сво вместе с хвостовой об лавшийся обнаженным продолжает работать. имеет два небольших тели, обеспечивающих на заданную траектори маршевого двигателя. зают собой герметичны отделяются. Стенки от что корпус сохраняет годаря внутреннему

Но уже упом К. Эрике основная нетной станции «А модифицированных то санной, но несколько кеты. После выхода пе расположенную на выс

ис. 97. Американ- кая межконтинен- альная баллистиче-

SOVIET-PUBLISHED data on Atlas.

In view of the above, I shall be grateful if you will let me know whether you can send us some photographs, data, fact-sheets, booklets, etc., which we could use in our public lectures or our Correspondence course.

In this way and with these small means we will attempt to make our small contribution to Science and to the cause of the Western World.

Fabio M. Berto
General Secretary
Astronautics Sciences and Space Technology Diffusion Center
Trieste

M/R has mailed to Mr. Berto 25 copies of its Fifth Annual World Missile/Space Encyclopedia. We forwarded a copy of his letter to USIA chief Edward R. Murrow.—Ed.

More Dean Pro & Con

To the Editor:

As a reader of M/R for its scientific information value, I take serious offense at the continuing debacle of the Dean Space Drive in your columns. The original obscure and confusing description of the system (M/R, May 1, p. 24) was followed by the customary crackpot claims, then by clearer but overelaborate disproofs. W. J. Lohninger's letter (M/R, Aug. 7, p. 6) is a return to such garbled rambling that it is unclear whether he is pro or con.

M/R is prejudicing its reputation as a credible source of missile science developments by persisting in reporting such pseudo-scientific claims as Dean's and his proponents'. A clear description of the principle of operation of the "Drive" and its logical disproof are topics on the elementary physics level and unworthy of a prolonged technical treatment.

I suggest abandonment of the topic and relegation of models of the "Drive" to the museum of perpetual motion machines (or to outer space under their own power).

Donald E. Wedekind
Cape Canaveral

To the Editor:

Since the publication of the article on the Rabinow Report on the Dean Drive (M/R, June 12, p. 24), I have been waiting to see a letter or an article pointing out the discrepancies in the report as presented. Apparently no one else has taken the trouble, so I'll do it myself.

Before I list the discrepancies I want to make one or two things clear:

1. Although I witnessed a demonstration of the Dean Drive over a year ago, the discrepancies I have indicated can be discovered by examination of the patent, the original article on the Drive (M/R, May 1, p. 24) and a good physics text.

2. I have no connection with Dean Systems Inc.

3. Your "Letters" department won't accommodate a detailed rebuttal, nor do I wish to take time at the moment to prepare one. . . .

There are three immediately apparent conflicts:

1. The first thing that caught my eye

when I looked at the article was the oscillogram. The May 1 article stated that the effective drive occurred through an angle of 60 degrees. The illustrations in the patent support this by the shape of the cams (fig. 6) and the choice of six pairs (fig. 11) to illustrate continuous thrust. The oscillogram shows an intense spike with a duration of slightly over 9 degrees (as determined with a ruler) with some positive "noise" extending for about 82 degrees (incidentally, where does that "noise" come from?). Obviously then, the oscillogram shows that the machine was not working at the time, but this does not prove that the machine can't work when it is operating properly.

2. The next thing that caught my eye in the May 24 article was the schematic. The May 1 article, the patent, and the figure on p. 42 of the May 24 article show the solenoid and the fixed springs attached to the fixed frame. The schematic indicates that they are attached to the load arm. If Mr. Rabinow had the machine set up as depicted in the schematic, the results he obtained are not surprising—but again that is not the way the system is designed, so the results don't apply to the Dean Drive.

3. The final item is a bit more subtle. Mr. Rabinow concluded that "The system does not have any unusual properties, nor does it contradict Newtonian laws of mechanics." On the next page he states that the "clutch grasps the load arm when the eccentric weights are on the far side of the load." Now (unless I have forgotten my physics), according to the classical laws of mechanics, when the weights are on the far side of the load, the carriage to which the clutch is attached would be moving in the negative direction—toward the load, not away from it. The fact that any positive force is exerted at that point indicates (to me at least) that Classical Mechanics needs a second look.

At this point I would like to insert some of my own speculations. A hundred years ago there was a Law of Conservation of Matter and a Law of Conservation of Energy—stated separately. The concept that one was a special case of the other would have been brushed off as not worthy of consideration, and it was "obvious" that changing the mass of a system without adding to or subtracting matter from an external system violated the Law of Conservation of Matter. Today there are Laws of Linear Motion and Laws of Rotary Motion separately stated, and it is "obvious" that changing the linear momentum of a system without adding to or subtracting from the linear momentum of an external system violates the Laws of Linear Motion. Could it be that the Dean Drive takes advantage of a hitherto-unnoticed relationship and that linear motion is a special case of rotary motion or that both are special cases of a general curvilinear motion not yet described? Incidentally, isn't the current consensus that space is curved, and that, therefore, there is no such thing as a straight line?

Finally, it is rather ironic that about a year ago M/R published an article on a study of field force propulsion (M/R, July 11, 1960, p. 27) which quoted an engineer to the effect that it "seems possible" to produce rectilinear motion in free space without expelling mass. The article goes on to imply maintenance of a 1-g environment within a vehicle accelerating at 100 g. Strangely enough, there wasn't a single letter of comment in the next five or six issues. Perhaps, because the article mentioned things like unified field theory, quantum mechanics and matter-to-energy conversion, readers were sufficiently awed so that they hesitated to challenge the idea. Apparently, the really shocking thing about the Dean Drive is not that it produces unidirectional motion, but that it is a simple mechanical device that any competent machinist can build with existing techniques and materials. . . .

Douglas P. Price
Kensington, Md.

Pride and Prejudice

To the Editor:

Re your Aug. 14 editorial ("Assignment: National Survival"):

The Aircraft Industry still associated with manned aircraft can still *command* pride. However, it is doubtful that the missile/space industry will reach a position deserving pride in the sixties.

Surely your self-admittedly trite comment will go down as outstanding for the decade.

If those of you in the missile/space industry want to do something for the good of the United States of America, how about selling the hardware of the industry to us at least at cost, as long as it is inferior merchandise?

Richard B. Monroe
Captain, USAF
Oxford, Ohio

To the Editor:

Congratulations on the editorial. I especially like the statement, "We have a nation full of people who have been asleep for years."

With respect to the next statement, "Until they wake up, we will continue to run second best to the Russians in this and many other fields," I predict that this will be true for a short time. Then, if no awakening occurs, we will fall further and further back to either being a satellite (non-space type) nation or a radioactive waste.

David W. Johnston
Washington, D. C.

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editorial . . .

SLAM: Time to Fish or Cut Bait

THE PUBLIC SPOTLIGHT turned on the highly-classified project *SLAM* in open congressional hearing this past week may do much to insure the program against meeting the same fate as the late-lamented aircraft nuclear propulsion program.

SLAM (supersonic low-altitude missile) is the nuclear-powered ramjet vehicle under development at Chance Vought, Marquardt Corp., and Lawrence Radiation Laboratory.

Officials of the Department of Defense, Air Force and the Atomic Energy Commission were called before the Joint Committee on Atomic Energy to testify on progress of the program.

Although funding for *SLAM* and its preliminary projects, *Tory* and *Pluto*, is as yet only a fraction of that of the abortive billion-dollar ANP program, committee members quite rightly expressed concern that *SLAM* might be starting down the same road.

The committee warned Dr. Harold Brown, DOD's research and engineering director, to keep a close eye on management of the program to prevent a repetition of the ANP debacle.

There are two schools of thought on what should be done to prevent *SLAM's* becoming another ANP program:

1. Kill it now without pouring into it the estimated $500 million it will take to develop a flight-test article.

2. Provide sufficient funds early enough to give the program a healthy growth schedule and carry it through to a successful conclusion.

One of these courses of action should be taken just as promptly as possible. The third alternative—a half-hearted effort on a drawn-out starvation budget—will only repeat the ANP disaster.

There seems little doubt at this point about feasibility of the nuclear-powered ramjet vehicle. Critical element in the *SLAM* system is the reactor, and the success of the *Tory IIA* test in Nevada on May 14 indicated problems in this area are being solved.

"It is possible to make a reactor with the assumed characteristics," Dr. Brown assured the committee.

The big question mark hanging over *SLAM* is whether an operational requirement for it actually exists. The Air Force and DOD attitude toward the program has been lukewarm.

Committee members were somewhat miffed by the fact that, whereas top officials of NASA and AEC were on hand for the previous day's hearing on Project *Rover*, the Air Force sent what the committee considered its third string to the *SLAM* hearing.

An Air Force witness testified that *SLAM* had been downgraded from priority Category II to Category III. The B-70, by contrast, is Category I. He disclosed that DOD has frozen $5½ million of the $7 million set aside in the Fiscal 1962 budget for *SLAM*.

"The Department of Defense has not yet formulated plans to utilize the capabilities of a nuclear-powered ramjet vehicle," Dr. Brown told the committee.

IT ALL ADDED UP to very half-hearted support of the program. Rather than suggesting a go-ahead for a flight-test program, the Air Force proposed expansion of ground testing.

Dr. Brown's report that he had appointed an ad hoc committee to assist him in making his decision about continued development of *SLAM* also failed to impress the committee.

"One of the best ways to kill a program is to set up an ad hoc committee," Rep. Melvin Price (D-Ill.) told him.

The review by the ad hoc committee, which is due to report by the end of the month, is one of a number that have been carried out in regard to *SLAM*. The Air Staff made its own review following the successful *Tory IIA* test. It appears that the program indeed runs the risk of being reviewed to death.

But the ultimate review which may do the program in is that by top DOD brass. It must be decided whether *SLAM* is sufficiently attractive to warrant development as a full weapon system or whether, in fact, the B-70 offers a more attractive way of doing the same thing. A DOD decision against *SLAM* would not meet much opposition from B-70 proponents.

Industry members of the *SLAM* team privately express the opinion that the decision which must be made now is whether to kill the project or proceed immediately to a flight test program. Anything less, they feel, would be unsatisfactory.

We agree. Any compromise decision will only lead to another ANP program. And we think the Congressional committee has performed a worthwhile service in bringing the problem out into the open.

William J. Coughlin

Navigation by sure eye and steady hand

Ferdinand Magellan successfully steered his ships around the world with the aid of an "astronomical ring" . . . one of the navigational wonders of his age. Hung from the steady hand of a sure-eyed seaman, readings were taken by sighting through the rings. Set for the month and day of the week, this ingenious device employed the sun's declination to first determine latitude, then the hour and finally the meridional point of the ship's position.

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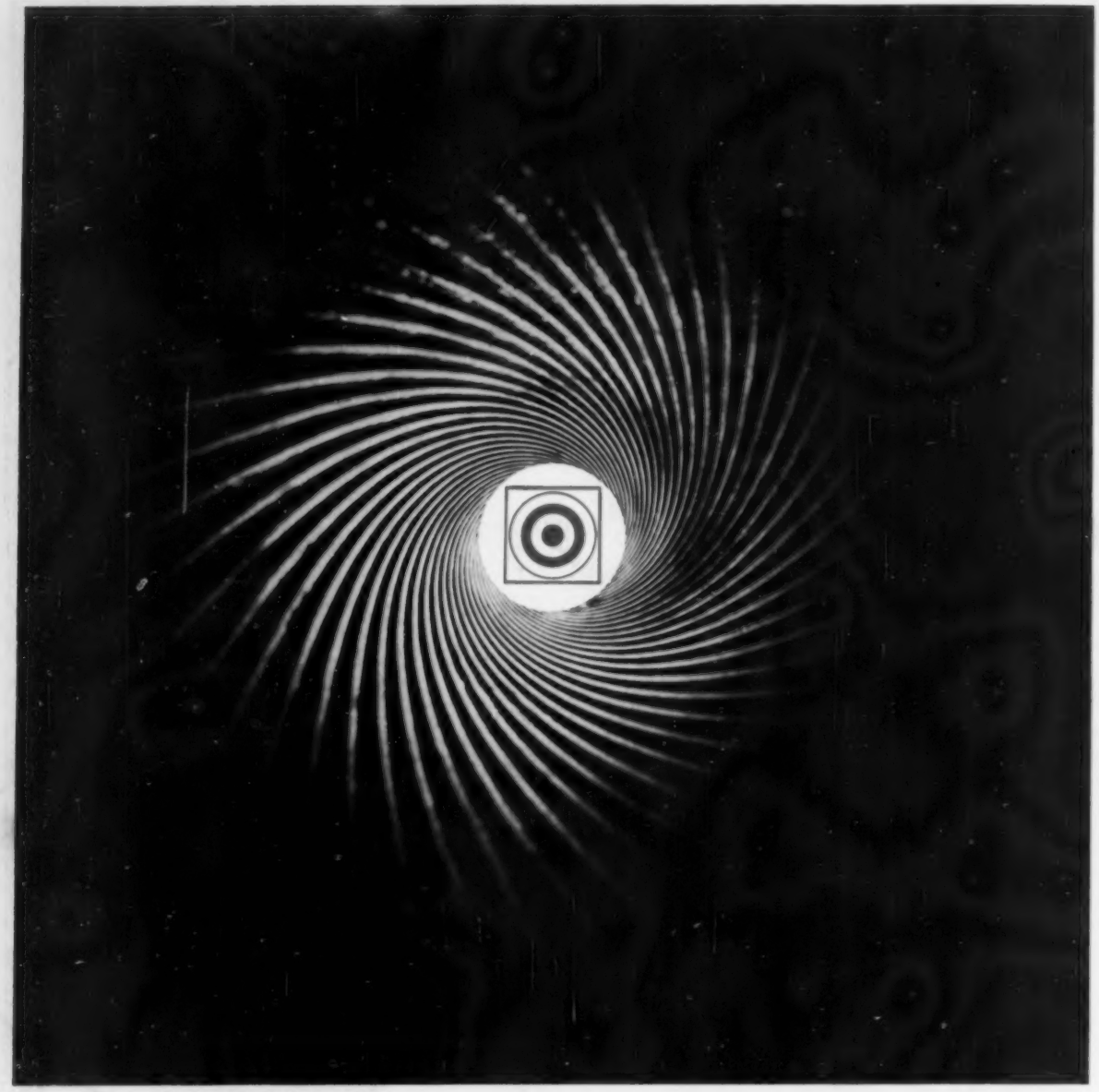

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